Introduction

Western Region
Sustainable Agriculture Research and Education

December, 1995

To: **All Interested Parties**

From: **V. Philip Rasmussen, Ph.D., Regional Coordinator**
Western Sustainable Agriculture Research and Education

Thank you for your interest in the Western USDA regional effort to expand knowledge and adoption of sustainable agriculture. This annual report documents the research achievements and program activities of the Western Sustainable Agriculture Research and Education, SARE, program in 1995.

It has been a challenging and fulfilling year for the regional program. We completed the administrative transition from the University of California to Utah State University, and at the same time, initiated two new competitive grants efforts targeted to area producers and agricultural professionals, and worked with our supporters to educate a new U.S. Congress about the values and accomplishments of SARE. In all of these endeavors, the Western SARE leadership and staff have excelled and achieved noteworthy success.

This report, for the first time, provides project "fact sheets" that outline the major objectives, results and potential benefits of funded research and education projects. In this packet are fact sheets on active projects only. Newly-funded efforts begin reporting results and accomplishments after at least one full year of continuing work. Additional copies of fact sheets are available individually as well as in this complete package. Highlights of program activities are addressed below.

Also in this package of materials are:

- listings of all SARE and Agriculture in Concert with the Environment, ACE, projects active this year;
- a table of current and cumulative grant awards organized by U.S. state or Island Protectorate;
- a comprehensive resource list of regional and national SARE publications and informational materials developed by SARE and ACE funded research and education teams;
- a fact sheet about Western SARE; and
- a "For Your Information" page (to pull out and keep) of contact names, addresses and phone numbers.

We hope you like this new format. It is easy to use as a package, or to file, copy and post as individual resource sheets.

Program Highlights

Western SARE administers four different grants efforts, which are targeted to area producers, researchers, and agricultural professionals.

Regional activities of special note in 1995 are:

- **Farmer/Rancher Research Grants.** Competitive grants for area producers were made available in 1995 for the first time. A total of about $100,000 was provided to individuals and groups of farmers and ranchers to identify, evaluate and test sustainable agriculture practices and challenges. Grant recipients must involve at least one local agricultural professional in their endeavors, and provide a plan for sharing gained information with others in their communities.
- **SARE and ACE Research Grants.** More than $1.1 million was awarded to the region's longer-term research programs, SARE and ACE, in 1995. The SARE program has been providing research support to sustainable agriculture studies since 1988 (formerly as the LISA program), and was mandated by Congress in the 1990 Farm Bill. The ACE, Agriculture in Concert with the Environment, program is a joint effort of USDA SARE and the U.S. EPA to encourage environmentally sound agricultural practices. Project proposals for consideration in 1995 were submitted by November 29, 1994.
- **Professional Development Program (Chapter 3).** The professional development team selected in 1994 to head this new effort completed the second competitive grants cycle in 1995. A Call for Proposals aimed at training extension agents and agricultural professionals in sustainable agriculture was released last fall. Proposals were due January 10, 1995; nearly $550,000 was given to selected projects. As part of the awards, potential grants of $12,000 to each state's or Island Protectorate's designated extension leader for sustainable agriculture were made available to help implement area strategic plans for this training effort.
- **New Regional Publication.** A new regional publication, "Eight Years of Progress," was done and distributed to diverse SARE audiences this year. It details with text, photography and quotations the accomplishments and values of the Western SARE program since its inception in 1988. (See "Resources" to order a copy.)

The regional program is directed by the Administrative Council (see "About Western SARE"), a leadership group that supports high quality research and education with minimal overhead and administrative costs. Funded projects are selected through a rigorous competitive review process, led by technical panels of experts with diverse professional backgrounds and geographic residences. Farmers and ranchers are involved in every level of decision-making. Projects are funded based on their merits and potential for achievement, and continual oversight of projects ensures that results are accurate and timely.

In cooperation with the U.S. Department of Agriculture Cooperative State Research, Education and Extension Service, we thank you again for your interest in sustainable agriculture and the progress of the Western SARE program.

This report was prepared by Kristen Kelleher, regional communications specialist, with assistance from Repro Graphics, UC Davis. Editorial direction was provided by V. Philip Rasmussen Ph.D., and Jill Shore Auburn, Ph.D.

About Western SARE

Western Region
Sustainable Agriculture Research and Education

Sustainable Agriculture Research and Education Program

The Western Sustainable Agriculture Research and Education, SARE, program is directed by a council of scientists, farmers and ranchers, business leaders and administrators, in cooperation with the USDA SARE office and the Cooperative State Research, Education and Extension Service.

Administrative Council members and officers in 1994-95:

- Jim Dyer, current chair (term: August, 1995 -), Dyer Environmental Consulting, Carbondale, Colorado
- Robert Heil, past chair (term: August, 1993 to August, 1995), Colorado State University, Ft. Collins, Colorado
- Ralph Nave, USDA Agricultural Research Service, Albany, California
- Janet Hren, U.S. Geological Survey, Menlo Park, California (until August, 1995)
- Valerie Kelly, U.S. Geological Survey, Portland, Oregon (beginning August, 1995)
- Jerry Schickedanz, New Mexico State University, Las Crucas, New Mexico
- Mike Somerville, USDA Natural Resource Conservation Service, Portland, Oregon
- Larry Thompson, farmer, Thompson Farms, Boring, Oregon
- Wilbur Wuertz, farmer, Casa Grande, Arizona
- Ray Bernal, agricultural real estate consultant, Phoenix, Arizona
- Dennis Teranishi, agronomy consultant, Pacific Islands
- Ex Officio National Program Representatives: Rob Myers, SARE program director; Jerry Dewitt, Iowa State University, Extension Service representative; Harry W. Wells, ACE grants director, U.S. EPA.

An interdisciplinary group of research and extension scientists — the Western Region Coordinating Committee (WRCC 67) — acts as the region's policy advisory committee. It meets annually to make recommendations to the Administrative Council about future directions of the Western SARE program. The advisory committee also acts as a "core" standing Technical Review Panel. The complete Technical Review Panel is appointed annually to correspond with the content of proposals to be reviewed in each grant effort. The panel includes farmers, ranchers, scientists, administrators and representatives of non-profit organizations and agri-businesses.

The Western Region encompasses Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming and the Island Protectorates of Guam, Micronesia, American Samoa and the Northern Mariana Islands.

For more information about Western SARE informational resources and publications, the region's competitive grants programs, or other questions, see the "For More Information" or "Western SARE Resources" pages.

Sustainable Agriculture Resources

Western Region
Sustainable Agriculture Research and Education

The SARE program puts high emphasis on getting research results and practical information on sustainable agriculture to those who need it in a timely and useful fashion. Following are resources for information on sustainable agriculture, most of which were developed by or with support from Western SARE, the national SARE program, or the Sustainable Agriculture Network (the national outreach partner for SARE programs).

If follow-up information is not given, contact the Western SARE public information office by phone at (916) 752-5987, fax at (916) 754-8550, or via e-mail to kkelleher@ucdavis.edu. The Western region also has a World Wide Web home page on the Internet at http://ext.usu.edu:80/wsare/. Calls for Proposals, recent news releases and other resources can be read or downloaded from this Web site.

Western SARE and National SARE Publications

To request any of these FREE publications, contact the Western SARE public information office.

- *Eight Years of Progress: 1988-1995.* An overview of eight years of accomplishments in the Western SARE program.
- *Western Region Annual Report, 1994*
- *National SARE Project Highlights (1995, 1994, and 1993 editions),* including brief and colorful highlights of research across the nation.
- *1994 National SARE/ACE Report to Congress*

Sustainable Agriculture Network, SAN : Publications, Databases, Internet

To order any of the following SAN materials, send a check or purchase order (or written request) to: Sustainable Agriculture Publications, Hills Building, University of Vermont Burlington, VT, 05405-0082. To inquire about bulk discounts and rush orders, phone (802) 656-0471. Or, contact the SAN Coordinator at (301) 504-6425, or via e-mail at san@nalusda.gov.

- *Profitable Dairy Options: Grazing • Marketing • Nutrient Management.* A brochure on sustainable dairy farming which focuses on rotational grazing, new marketing approaches and some references for feedlot-oriented systems. FREE.
- *The Sustainable Agriculture Directory of Expertise* (print or Folio software). A list of over 700 people and organizations willing to share their expertise in sustainable agriculture. Price: $14.95
- *The Showcase of Sustainable Agriculture Information and Educational Materials* (print or Folio software). A compilation of over 300 publications, videos and other materials. Each entry has a detailed product description and ordering information. Price: $4.95

- *The Real Dirt.* Farmers tell about organic and low-input practices in the Northeastern U.S. Price: $13.95
- *SARE and ACE Research Summaries* (Folio software only). Price: $7.50
- *Sustainable Agriculture vs. Weeds.* A FREE bulletin.
- *Getting Started Electronically with the Sustainable Agriculture Network.* A FREE bulletin.

Regional Newsletters

Pacific Northwest Sustainable Agriculture, Farming for Profit & Stewardship. Quarterly newsletter covering research, issues and resources on sustainable farming in the Pacific Northwest. FREE to subscribe. Contact: PNW Sustainable Agriculture, Dr. Jack Waud, 223 E. 4th, Port Angeles, WA, 98362 or phone (206) 452-7831.

Sustainable Agriculture (a publication of the University of California's Sustainable Agriculture Research and Education Program). This FREE quarterly publication provides practical information, announcements and technical and research summaries. For a list of other materials or to subscribe, contact UC SAREP at (916) 752-7556.

Western SARE Conference Proceedings, Videos, Guides, Handbooks & More

Developed with support from regional grants.

- *Farmer/Scientist Focus Sessions: A How-To Guide.* By Daniel Green-McGrath, Larry S. Lev, Helene Murray and Ray D. William. Order up to six free-of-charge. Contact: Publications Orders, Agricultural Communications, Oregon State University, Administrative Services, A422, Corvallis, OR, 97331-2119, or phone (503) 737-2513.
- *Whole Farm Case Studies: A How-To Guide.* By Helene Murray, Daniel Green-McGrath, Larry S. Lev and Alice Mills Morrow of Oregon State University. Order up to six free-of-charge. Contact: Publications Orders, Oregon State University at same address as above.
- *Whole Farm Case Studies of Horticultural Crop Producers in the Maritime Pacific Northwest.* Contact: Publications Orders, Oregon State University, at same address as above.
- *A Resource Guide to Sustainable Agriculture in Washington and Oregon.* A resource guide of more than 200 pages tailored to this region. No charge while supply lasts. Contact: Guide # EM8531, Publications Orders, Oregon State University, at same address as above.
- *Issues in Sustainable Agriculture: A Study of Horticultural Producers in Western Oregon and Washington*
- *Participatory On-Farm Research and Community Involvement in Agriculture and Environmental Issues: An Annotated Bibliography,* January 1980 - May 1992
- *Facilitator's Guide to Involving the Public in Applied Agricultural Research: Planning and Coalition Building,* August 1992
- *Cropping Strategies and Water Quality 1993 Annual Report*
- *Land Grant University Agriculture and Natural Resources Research: Perceptions and Influence of External Interest Groups*
- *Farming For Profit and Stewardship, Sustainable Agriculture in the Pacific Northwest.* Proceedings of the West Cascade Conference for 1989, 1990, 1991.
- *Farming For Profit and Stewardship, Sustainable Agriculture in the Pacific Northwest, 1989.* Proceedings of the Tri-State symposium. Contact: Department of Agronomy and Soil Science, Washington State University, Pullman, WA, 99164-6420.

- VIDEO: *Creative Cover Cropping in Perennial Farming Systems.* How to use cover crops in orchards and vineyards to improve soil fertility, enhance pest control and provide other benefits. Price: $20. Contact: UC SAREP, University of California, Davis, CA, 95616, or phone (916) 752-7556.
- VIDEO: *Creative Cover Cropping in Annual Farming Systems.* Cover cropping in row and field crop systems. Price: $20. Contact: UC SAREP at same address as above.
- *On-Farm Testing: A Grower's Guide.* Contact: Cooperative Extension, College of Agriculture & Home Economics, Washington State University, Pullman, WA, 99164-6420.
- *1992 Alternative Crop Rotation Enterprise Budgets, Whitman County, Washington.* Contact: Department of Agricultural Economics, Department of Crop and Soil Sciences, Cooperative Extension, Washington State University, Pullman, WA, 99164-6420.
- *Long-Term Management Effects on Soil Productivity and Crop Yield in Semi-Arid Regions of Eastern Oregon,* November 1989. Contact: Paul E. Rasmussen, USDA - Agricultural Research Services, Columbia Plateau Conservation Research Center, P.O. Box 370, Pendleton, OR, 97801. Phone: (503) 276-3811.
- *Dryland Farming In The Northwestern United States.* Contact: Washington State University, Cooperative Extension, Pullman, WA, 99164-6420.
- *Washington Agriculture: Sustaining Water, Land and People,* Clean Water for Washington. Contact: Bulletins Office, #EB1634, Cooperative Extension, Washington State University, Pullman, WA, 99164-5912.
- *Prospects For Sustainable Agriculture in the Palouse: Farmer Experience and Viewpoints,* 1990. Contact: Washington State University, Pullman, WA, 99164-6420.
- *Amber Waves,* 1992. Contact: Bulletins Office, #XB1025, Cooperative Extension, Washington State University, Pullman, WA, 99164-5912.
- *Protecting Ground Water From Agricultural Chemicals: Alternative Farming Strategies For Northwest Producers.* Contact: AERO, 25 So. Ewing, Suite 214, Helena, MT, 59601. Phone: (406) 443-7272.
- *Proceedings of AERO's Soil-Building Cropping Systems Conference. Contact:* AERO at above address.
- *Taro Production Systems In Micronesia, Hawaii and American Samoa.* Contact: L. Ferentinos and A. Vargo, American Samoa Community College, Pago, Pago, AS.
- *Sustainable Taro Culture in the Pacific, The Farmers Wisdom.* Contact: Pacific Agricultural Development Office, Tropical Energy House, East-West Road, University of Hawaii, Honolulu, HI, 96822. Fax: (808) 956-6967.
- VIDEO: *Nourish The Roots Gather The Leaves - Sustainable Taro Culture in the Pacific.* American Samoa Community College, Pago, Pago, AS.
- *Cereal-Legume Cropping Systems: Nine Farm Case Studies in the Dryland Northern Plains, Canadian Prairies, and Intermountian Northwest.* Contact: Alternative Energy Resources Organization (AERO), 25 So. Ewing, Suite 214, Helena, MT, 59601. Phone: (406) 443-7272.
- *Sustainable Agriculture in the Northern Rockies and Plains.* Contact: AERO at above address.
- *Cover Crops for Clean Water.* Proceedings of an international conference. Edited by W. L. Hargrove; authored by J. R. Sims and A. E. Slinkard.

- *Western Farm Management Extension Committee, Total Resource Budget Compendium,* August 1992
- Proceedings of Livestock Health and Nutrition Alternatives: A Western States Conference. Contact: AERO at above address.
- AUDIO TAPE: *Perspectives on Solarization.*
- AUDIO TAPE: *Habitat For Diversity and Pest Control.*
- *Sustainability of Range Livestock Production Systems in the West,* proceedings of a September, 1994, regional conference. Sponsored by Montana State University, MSU Extension and Western SARE.
- VIDEO: *Fire & Water Restoration of a Pinyon-Juniper Watershed.* Contact: USDA Soil Conservation Service, RC&D Program, Box 457, Carrizozo, NM, 88301. Phone: (505) 648-2941.
- *Restoration of A Pinon-Juniper Ecosystem* (Companion to Video). Contact: USDA Soil Conservation Service at above address.
- *Crop and Livestock Production Systems for Land in the Conservation Reserve Program, 1994 Progress Report,* New Mexico State University Cooperative Extension and Agricultural Experiment Station. Contact: Rex Kirksey, New Mexico State University, Agricultural Science Center, 6502 Quay Road, AM.5, Tucumcari, NM, 88401.
- *Intermountain Workgroup "How To" Monitor Rangeland Resources,* (Level 1, Beginning), University of California Cooperative Extension, December, 1994. Contact: UCCE, County of Tehama, P.O. Box 370, 1754 Walnut Street, Red Bluff, CA, 96080. (Note: "Level 2, Advanced" is due for release in December, 1995.)
- *"Permaculture-Sustainable Farming, Ranching, Living...by Designing Ecosystems that Imitate Nature,"* Central Rocky Mt. Permaculture Institute. Contact: Jerome Osentowski, Central Rocky Mt. Permaculture Institute, P.O. Box 631, Basalt, Colorado, 81621, (970) 927-4158. Internet: http://sunsite.unc.edu/london/permaculture.html.

For More Information

Western Region
Sustainable Agriculture Research and Education

The Western SARE program staff is available to answer your questions and provide you with specifics on the region's competitive grants efforts, available publications and informational resources on sustainable agriculture. The national SARE office and the Sustainable Agriculture Network (the SARE program's national outreach and information partner) are also available to serve your needs.

General and grants program information:

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Western Region SARE Office
ASTE Building
Utah State University
1500 North 800 East
Logan, UT 84322-2310
tel: (801) 797-3537
fax: (801) 797-4002

Rhonda Miller, program manager
(at Western Region SARE office address)
tel: (801) 797-0351
rlmiller@cc.usu.edu

Western Region SARE World Wide Web Site: http://ext.usu.edu:80/wsare/

Professional development , or "Chapter 3," grants and training information:

Jill Shore Auburn, regional training coordinator
SARE
University of California
Davis, CA 95616
tel: (916) 754-8548
fax: (916) 754-8550
jsauburn@ucdavis.edu

Public information (and publications):

Kristen Kelleher, communications specialist
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Davis, CA 95616
tel: (916) 752-5987
fax: (916) 754-8550
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National SARE program:

Rob Myers
Director, SARE Program
USDA/CSREES
3851 South Building, Ag Box 910
Washington, D.C. 20250-0910
tel: (202) 720-6283
fax: (202) 720-4924
e-mail: rmyers@reeusda.gov

Sustainable Agriculture Network, or SAN:

SAN is an information exchange effort and the national outreach partner of the USDA SARE program, involving universities, government, producers, businesses and non-profit organizations. SAN has books, flyers, directories and software on sustainable agriculture topics available.

Andrew Clark
SAN Coordinator
c/o Alternative Farming Systems Information Center, Rm. 304
NAL/ARS/USDA
10301 Baltimore Blvd.
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Western Region

Sustainable Agriculture Research and Education

Utah State University
ASTE Building
1500 North 800 East
Logan, Utah 84322-2310

Annual Results

SARE #92-4

Sustainable Farming Quarterly

Location:
Oregon, Washington, Idaho, Montana, Wyoming and Utah

Funding Period:
October, 1992 -

Grant Award:
$17,500

Project Coordinator:
Nancy Matheson, Executive Director
Alternative Energy Resources Organization (AERO)
25 South Ewing, Suite 214
Helena, MT 59601
Phone: (406) 443-7272
Fax: (406) 442-9120
E:mail:
nancy_matheson@desktop.org

Objective

To accelerate the transfer of regionally appropriate sustainable farming technical information to producers, agriculture researchers and technical assistance providers in the six-state area of Oregon, Washington, Idaho, Montana, Wyoming and Utah.

Abstract of Results

The Alternative Energy Resources Organization has published the *Sustainable Farming Quarterly* (SFQ) since December 1989. Today the SFQ reaches over 1900 farmers, ranchers, extension personnel, Soil Conservation Service staff, universities and news editors in the Inland Northwest and Northern Rocky Mountain regions. The eight-to-twelve page quarterly presents research findings, farmers' perspectives and timely information on sustainable agriculture initiatives in an easy-to-read format. The focus is on cereal-legume cropping systems of the six-state area. The mailing list continues to expand both regionally and nationally. Under AERO's current SARE contract, five of the originally planned eight issues have been published thus far. We anticipate publishing a January and March issue in 1995. By the end of this contract AERO will have published seven, not eight, issues as originally anticipated.

According to reader surveys conducted in late 1990 and again in November 1992, the SFQ is a useful source of information for technical assistance providers and is a good management tool for farmers. Several readers responded in the last survey that the SFQ keeps them informed about the new directions in agriculture and exposes them to new ways to solve problems.

Articles on research activities and outcomes rated the highest in popularity. SFQ recipients overwhelming saw the SFQ as a unique source of information — delivering information they don't get elsewhere.

The SFQ solicits articles from scientists, farmers and government agencies. The six state Extension offices and the Montana Natural Resource Conservation Service circulate the SFQ to all their field staff and offices. All other copies are mailed to individual subscribers.

Potential Contributions

Surveys of SFQ readers demonstrate the value of the periodical in the region. However, the actual on-farm impacts or benefits have not been measured. About half of the 1993 reader survey respondents were farmers and half non-farmers. All but four respondents to the late 1993 reader survey rated the SFQ very useful or useful. Many said they refer to the SFQ on a regular basis and share it with colleagues, friends and students. Some of the readers use it in their university classes to expose students to alternative agriculture practices. In addition, private agriculture publications often pick up stories from the SFQ related to sustainable agriculture in the region. The SFQ has made a significant contribution to raising the awareness and acceptance of sustainable agriculture practices as a viable alternative to conventional options.

Farmer Comments

In general people complimented the SFQ for covering on-farm test results and the specific sustainable practices being used in this region. Examples from AERO's 1993 reader survey include a Montana farmer saying, "all (articles) are interesting and useful for keeping me informed of new approaches to solving problems."

A Washington State farmer commented, "It is important that sustainable agriculture has a medium to inform and educate farmers, scientists and political decision-makers about sustainable farming practices. This needs to be accomplished by using scientific research, and on-farm testing by farmers working with scientists. The SFQ is the best medium to inform all people who use the land, and the politicians to accomplish this media goal. I suggest you broaden your mailing list to include all Washington, D.C., Senators and Congressmen. Their aides need this information."

Reported in 1995

Western Region
Sustainable Agriculture Research and Education

Utah State University
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1500 North 800 East
Logan, Utah 84322-2310

Annual Results

SARE #93-33

Development of Sustainable Crop and Livestock Production Systems for Land in the Conservation Reserve Program (CRP)

Location:
Eastern New Mexico

Funding Period:
September, 1993 -

Grant Award:
$312,000

Project Coordinator:
Rex E. Kirksey,
Superintendent
New Mexico State University
Agricultural Science Center
6502 Quay Road AM.5
Tucumcari, NM 88401
Phone: (505) 461-1620
Fax: (505) 461-1631
E-Mail:
tucumcar@NMSU.edu

Objectives

The overall goal of the project is to develop economically viable crop and livestock production systems to extend the wildlife and environmental benefits of the Conservation Reserve Program (CRP) beyond the ten-year contract period while maintaining compatibility with existing production systems, established farmer goals and external production constraints. Specific objectives are:

1. Develop livestock grazing systems for the predominate grass species growing on CRP land.
2. Identify dryland cropping systems for converting CRP grassland to sustainable crop production.
3. Compare the potential environmental impacts of the production systems evaluated in Objectives one and two with traditional crop and livestock production systems and current use of CRP land.
4. Identify and demonstrate techniques for improving and maintaining wildlife habitat on CRP and post-CRP lands.
5. Conduct an economic evaluation of alternative production systems including: (a) whole farm cost and return analysis, (b) short- and long-term profitability analysis, and (c) risk analysis.
6. Determine the compatibility of potential production systems with existing production systems, established farmer goals and external production constraints.
7. Develop an information delivery component to: (a) demonstrate various crop and livestock production systems and (b) disseminate scientific, technological and economic information to agricultural producers.

Abstract of Results

The Conservation Reserve Program (CRP) is a voluntary long-term cropland retirement program whose primary goal is to reduce soil erosion on highly erodible cropland. One of the highest CRP participation rates in the nation is found in a six-county area of Eastern New Mexico. In the counties of Curry, Harding, Lea, Quay, Roosevelt and Union, 29 percent of the total cropland acreage is currently enrolled in CRP.

Under the current farm program, all CRP land in Eastern New Mexico will be eligible to return to productive use within the next five years. If the conservation benefits of the CRP are to extend beyond the initial contract period, sustainable crop and livestock production systems must be developed, evaluated and implemented before contracts begin to expire.

This project is evaluating land use alternatives that may be available to CRP contract holders when the current program expires. Through the use of on-site grazing trials, it has been demonstrated that weeping lovegrass can be successfully utilized for cattle grazing. Cattle weight gains were high during the early portions of the 1994 growing season but declined as the grazing season progressed and the grass matured. There appears to be potential to improve pasture productivity by manipulating forage quality through grazing/rest rotations and nitrogen fertilization.

Cropping trials are evaluating various techniques for converting CRP grassland back to annual crop production. In 1994, the conventional tillage system produced higher yields of grain sorghum than the minimum tillage and no-till systems. It appears the low yields of the reduced tillage systems were due to lack of available controls for annual and perennial grasses. The project has demonstrated that wildlife habitat can be installed and maintained with a minimum of time, expense and effort. Regardless of the future use of existing CRP land, small areas should be maintained in permanent vegetation and developed for wildlife habitat.

Potential Contributions

This project has demonstrated there are a number of possibilities for post-CRP land use. Cattle can be successfully grazed on weeping lovegrass (the predominate species planted on CRP land in New Mexico). Early season grazing may be crucial to the economic success of grazing livestock. Weeping lovegrass biomass production and weight gains of grazing cattle can be increased through applications of nitrogen fertilizer. If vast acreages of CRP land can be maintained in permanent cover and utilized for livestock grazing, potential erodibility can be reduced.

The project has shown that it is possible to successfully convert CRP land back to annual crop production. However, it may not be possible to control perennial grass weeds in limited and no-till production systems unless seedbed preparation is preceded by an extended period of intensive weed control. It may be necessary to use conventional tillage during the first year of crop production with a planned switch to a minimum tillage system in subsequent years.

The project has shown that wildlife habitat can be established with a minimum of time, expense and effort. Whether CRP is eventually converted to cropland, grazing land or some alternate use, small areas should be maintained in vegetative cover and developed as wildlife habitat.

Farmer Comments

"I am more optimistic that there is potential for grazing weeping lovegrass now that I have seen what you are doing."

— Ross Duke

"I was impressed. It looks like its proving its worth if people will follow through with what you're doing."

— Henry Bugg

"The CRP Field Tour was real good, especially the grazing thing. I heard some good comments: One cattle farmer said, 'It is something I've been needing to know.' Another commented, 'It is a real good research project.' On the cropping plots, a couple of farmers said they need more information over a longer period of time. And, I'm sure we need the same on grazing."

— Victor Stout

Reported in 1995

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Annual Results

SARE #93-34

Four-Corners Navajo Nation Sustainable Agriculture Demonstration Project

Location:
Four Corners Region (of Arizona, Utah, New Mexico, and Colorado), Navajo Nation

Funding Period:
September, 1993 -

Grant Award:
$300,000

Project Coordinator:
Lyle G. McNeal, Professor, Animal Science & Director, Navajo Sheep Project
Animal, Dairy & Veterinary Science Dept.
Utah State University
Logan, UT 84322-4815
Phone: (801) 797-2150
Fax: (801) 797-2118
Email: Sheepman@cc.edu.usu

Objectives

1. To develop and sustain improved socio-economic conditions for Navajo agro-pastoralists, while maintaining cultural integrity through the preservation of the traditional 'Navajo Lifeway'.
2. To develop integrated systems to maximize output from Navajo agro-pastoral production practices, while minimizing negative environmental impacts, which includes soil, plant, energy, waste management and water quality considerations.
3. To develop a trans-disciplinary whole-farm systems model for sustainable Navajo rural economic development. The process would incorporate a two-way cross-cultural transfer of agro-pastoral technologies.
4. To provide on-site mentoring by a trained Navajo; develop entrepreneurial skills, and cultivate leadership proficiency among the Navajo cooperator participants.
5. To establish a Four-Corners Sustainable Agriculture and Natural Resources Advisory Council, made up of participants representing elected officials, federal and state government agencies, land-Grant Universities, private enterprise and other appropriate organizations representing the States of Arizona, Utah, New Mexico, and Colorado and the numerous Native American reservations that encompass the Four-Corners Region.

Abstract of Results

At the time this report was written, the project was in its "start-up" phase; there are no results to report yet.

Potential Contributions

1. There will be development of an economical, life-cycle nutritional management plan for each cooperators' livestock units. This will result in more productive livestock, managed within the context of an annual management calendar, which designates planning that optimizes the utilization of environmental resources within the pastoral system.
2. Establishment of portable water systems will raise the standard of living and reduce fossil fuel energy expenditures in the trafficking associated with water related access. Appropriately designed portable systems should reduce health risks for humans and livestock, facilitate improved livestock distribution, management and open up greater opportunities for agronomic and horticultural activities.
3. Grazing management, seasonal rangeland grazing and woody plant management will improve plant and animal productivity and reduce erosion.
4. Rediscovery of traditional cultivation techniques and areas coupled with investigations on new varieties and current cultural practices will result in a resurgence of interest in historic agronomic and horticultural practices. This should create more nutritious, palatable and productive food sources and, with the increased production, additional market opportunity.
5. Provide opportunities for value-added and home-based business enterprises related to the sustainability of the traditional and cultural concerns. By doing so this will help economically self-empower the matriarchal system.

Farmer Adoption

The following are reported Navajo cooperator families' comments relative to changes already made since the project began:

1. First and importantly, a trusted relationship with the project team has been established.
2. Selection of sound breeding rams and billies.
3. Ear tagging and identification of all livestock.
4. Designated breeding seasons (instead of leaving males in year-long).
5. Castration of undesirable males.
6. Separation of males during the off-season.
7. Elimination of unused horses.
8. Some electric machine shearing, rather than hand-blades (where power is available).
9. Improved wool harvesting practices, skirting tags.
10. Designing and improving livestock working facilities.
11. Initiation of record keeping system.
12. Family planning meetings to discuss agricultural practices.
13. Some alterations in grazing management, i.e. salt placement on range.
14. Value-added processing of 1994 wool clip.
15. On and Off-Reservation direct marketing of surplus breeding stock.

Farmer Comments

"After just one year of the (project), we have hope for the future and I am happy when I see my oldest son, age 9, helping out with the sheep. This year I will help my son and some other children in the area start a 4-H project with sheep and gardening."

— The Sharon Begay Family, Ganado, AZ

We feel this project will provide us hope and reality for retaining our animals, land, and cultural values necessary to Navajo Life."

— Joe and Carol Benally, Pinon, AZ

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Annual Results

ACE #-91-5

Soil Bacteria To Control Jointed Goatgrass in Integrated Cropping Systems

Location:
Dryland region of Pacific Northwest, near Pullman, Washington.

Funding Period:
January, 1991 - December, 1994

Grant Award:
$60,000

Project Coordinator:
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Objectives

Develop the use of soil bacteria as an alternative management tool to control jointed goatgrass with emphasis on winter wheat.

Determine the influence of environmental stresses on the activity and survival of weed-suppressive bacteria.

Determine the economic impact of jointed goatgrass densities and the effect of bacterial treatments on yields of winter wheat and other rotation crops.

Develop a management technology that integrates weed suppressive bacteria with cultural and chemical methods for economic control of jointed goatgrass in small grain cropping systems.

Transfer to growers and industry the technology of using weed-suppressive bacteria to control jointed goatgrass in small grain cropping systems.

Abstract of Results

Jointed goatgrass (Aegilops cylindrica) is fast becoming a major threat to fall-sown small grains and now infests an estimated 5 million acres in the U.S. and reduces growers net income by $145 million annually. Selective herbicides for its control are not available and the only alternatives

are intensive tillage, which increases erosion, or spring cropping which reduces crop diversification and grower's profits.

The objective of this research was to develop a novel and safe biological weed control technology that should significantly reduce costs and the need for tillage and chemical herbicides to control grass weeds in small grain crops.

Six bacterial isolates were studied in depth. In greenhouse studies, weed-inhibitory bacteria reduced jointed goatgrass growth from 30 to 70 percent. In 1993 and 1994 field trials, several isolates tested were effective in reducing emergence of the jointed goatgrass. In 1993, two of the four isolates suppressed aboveground growth by 20-30 percent. In 1994, three of the six isolates suppressed jointed goatgrass above ground growth from 27 to 75 percent. No root data was taken. We also have found that different jointed goatgrass accessions, collected from various sites in the Western U.S., were more diverse in their response to the inhibitory bacteria than other weed species, which may indicate a greater genetic diversity of this weed than had originally been suggested. Greenhouse and field studies showed that the bacteria in combination with induced plant stresses such as reduced level of herbicides or root growth inhibitors were more effective in reducing plant growth than either treatment alone. We have found the bacteria to be more inhibitory when used in combination with sub-lethal doses of a synthetic chemical herbicide.

We followed the survival of introduced bacteria in soil and on roots. Fall introduced bacteria declined in the soil to near or below detection during the winter, but increased in the spring. The bacteria colonized roots during the fall, winter, and spring then declined with summer. Even though the bacteria in the soil declined to below detection, a sufficient population was present to colonize the root. We also investigated the use of delivery systems. When encapsulated in various formulations, bacterial survival increased 20 to 40 percent. Desiccation tolerant strains were better able to survive low moisture, thus may be better suited for field application. *Using soil microorganisms to control weeds or for other agricultural purposes is a promising alternative method to reduce crop production costs, decrease dependence on pesticides, and increase the use of environmentally sound practices.*

Economic Analysis

The economic analysis cannot be conducted at this time due to lack of information on this new technology. We propose to conduct the economic analysis in the future after more data is collected on the impact of these bacteria on jointed goatgrass. Since $145 million is lost annually due to this weed, this biocontrol technology potentially has a major impact on grower's net return.

Potential Contributions

This study is helping to develop and implement a novel and safe biological weed control technology that should significantly reduce costs and the need for tillage and chemical herbicides to control grass weeds in small grain crops. The only alternatives for weed control are intensive tillage, which increases erosion, or spring cropping, which reduces crop diversification and grower's profits. Besides lower input costs, the biological control technology should help growers reduce erosion and water pollution by enabling them to use conservation cropping systems. These types of systems are both profitable and ecologically sound while maintaining water quality.

This research has a much larger outcome than just weed control. This work will foster an extension of the new knowledge of microbial processes such as survival in soil, specificity, secondary metabolite production, and rhizosphere colonization. This information can be used for other research purposes such as utilizing microorganisms as a mechanism for delivery of any desired compound to the root surface. It can also help scientists to understand how the soil microbial component can be managed to reverse soil degradation and aid in maintaining a healthy and productive soil.

Farmer Adoption

This technology requires a paradigm shift on the part of the user group because weed control is occurring without the sole use of a synthetic chemical. In this biocontrol system, synthetic chemicals are replaced or used at a reduced rate in conjunction with the biocontrol agent. Until now it was considered necessary to have near 100 percent control of the weed. When one considers the impact microorganisms can have on the competitive abilities of a plant by just suppressing plant growth, total control of the weed population is not required. The competition of the crop with the weed is a major concept in this biocontrol system, which involves consideration of the ecology of both the weed and the bacteria for successful weed control. This plant-microbe interaction along with the weed-crop interaction will effectively reduce the weed pressure and attain the true yield potential.

Recommendations of operational changes cannot be made at this time. Once a greater knowledge base is developed pertaining to the use of bacteria for weed control and products that are on the market, then growers will be able to choose a microbial product and reduce pesticide use. Also of consideration is the use of microbial products for other reasons. Microbial products should be tested on each individual farm with strip or test plots before whole farm use. Microorganisms may be site or soil specific and may not function in all situations. Also, these microbes are living and need to be treated carefully.

New Hypothesis

Using soil microorganisms to control weeds or for other agricultural purposes is a promising alternative method to reduce crop production costs, decrease dependence on synthetic chemicals, and increase the use of environmentally sound practices. This research clearly demonstrates the potential for use of naturally-occurring plant growth inhibitory bacteria as a novel non-chemical approach for controlling grass weeds in cereal crops. A paradigm shift is required which focuses on natural microbes in an agroecosystem. The bacteria are used as the delivery system for the natural compounds they produce. The concept of applying a small amount of bacteria to naturally colonize the root requires the consideration of the ecology of that bacteria in soil and on the root.

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Annual Results

ACE #92-6

Cover Crops Incorporated with Reduced Tillage on Semi-Permanent Beds: Impacts on Nitrate Leaching, Soil Fertility, Pests, and Farm Profitability

Location:
Salinas, California

Funding Period:
August, 1992 -

Grant Award:
$133,200

Project Coordinator:
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Objectives

1. Quantify the potential for new cover crop/reduced tillage systems on semi-permanent beds to improve nitrogen (N) cycling and decrease nitrate (NO_3^--N) leaching as compared to conventionally farmed systems.
2. Compare vegetable crop yields on cover-cropped/reduced tillage and conventionally-farmed management systems.
3. Develop innovative reduced tillage practices that minimize time and energy requirements for cover crop incorporation.
4. Determine positive and negative effects of cover crops and reduced tillage on disease and insect pests.
5. Calculate costs and benefits of each management system to determine relative profitability, energy savings, and labor requirements associated with using cover crops and reduced tillage on semi-permanent beds, using a computerized budget generator (Budget Planner).
6. Utilize a soil/plant process model (EPIC) to assess short-term and long-term effects of using cover crops and reduced tillage on crop productivity, leached NO_3^--N, and profitability.
7. Conduct field demonstrations and local meetings, and prepare publications to inform growers of the environmental advantages, management feasibility, risks, and profitability of adopting cover crops and new tillage practices.

Abstract of Results

Development of new management practices is necessary for annual row crops, which use large amounts of nitrogen (N) and water, and create a high potential for groundwater contamination by nitrates (Letey *et al.*, 1978; Keeney 1982; Magdoff, 1991). Our previous work has shown that in intensive vegetable production systems, winter cover crops can deplete soil nitrate (NO_3^--N) during the winter rainy season, and improve soil N recycling after incorporation, even when there is only a short fallow period between vegetable crops (Jackson *et al.*, 1993a; b).

One purpose of this project is the development of cover crop management techniques, including reduced tillage on semi-permanent beds, which are cost-effective and practically suited to intensive vegetable production schedules. Research plots were established in 1992 at three commercial farm sites. These sites were cover cropped during the winters of 1992-93 and 1993-94, and then planted with two successive vegetable crops in both years. The soil types at these sites range from loam to clay.

The short-term effects of cover crop incorporation, including plant N availability, insect and disease incidence, and soil nitrogen and microbial biomass, were the focus of intensive post-incorporation soil sampling at all three sites in the spring of 1993. Cover crops significantly reduced soil NO_3^--N during the winter at all of the sites. High NO_3^--N levels in the lower soil depths of the bare plots at all sites persisted into the early stages of vegetable production, when frequent irrigation causes leaching.

The post-incorporation soil data suggests that after one year of winter cover cropping, the changes in soil N dynamics which occur following cover crop incorporation are short-term and temporary, and are usually not detectable by the time the first cash crop is planted. There was no apparent increase in soil N availability for crop uptake after one year of cover cropping, based on crop yield and N content. Sustained differences in soil N content and microbial biomass, however, were found to extend into the vegetable crop period at the site which was cover cropped for two successive years.

Data collected after the second and third years of cover cropping at the other study sites will provide important information on the cumulative effect of cover cropping on crop N availability. A soil/plant process model (EPIC; Sharpley & Williams, 1990) has now been calibrated for the cover crops used in

this study, as well as for broccoli and lettuce, the two vegetable crops grown at the field sites. The model will be used to simulate management practices and predict their outcome on a broader scale than is possible from field measurements alone.

To more precisely identify the fate of cover crop N following incorporation, an additional cover crop trial was established in November 1993 on research plots, to permit more in-depth analysis of soil processes which are difficult to conduct on commercial fields. This trial consisted of a main plot area to compare two cover crop species with a winter-fallow control. In addition, deep PVC cylinders containing undisturbed soil were installed adjacent to this area, into which cover crop shoots and roots labeled with isotopes of N and carbon (C) were incorporated at the time of cover crop incorporation in the main plots. This will enable analysis of the exact fates of cover crop-derived N and C among the various sinks in the crop ecosystem. Increases in certain soil arthropods and fungal sclerotia, which were found in some cover cropped plots after incorporation, did not persist into the vegetable cropping period, and had no effect on crop yield. Detailed management input records were compiled for each commercial site to allow a comparison of energy use, labor requirements and costs of cover cropping, using a computerized budget generator. Preliminary analysis indicates the costs of cover cropping are minimal relative to the costs of other standard winter management practices.

Economic Analysis

Management input records compiled for each commercial site were entered into a computerized budget planner to calculate gross returns, total cost, and profitability of winter cover cropping within the context of an intensive, year-round vegetable cropping system. The cost of growing a cover crop is low compared to the cost of other winter management practices. A rain-fed phacelia cover crop cost roughly $50/acre to produce, which is only 2-3% of the cost of growing one vegetable crop. It appears that the more significant risk in winter cover cropping lies in the potential for lost revenue if the cover crop disrupts the vegetable planting schedule. The window of opportunity to grow and incorporate a cover crop, and then prepare the field for vegetable planting is very short in this production system. The use of semi-permanent beds and minimum tillage techniques may be the critical management component to make cover cropping a viable option in intensive vegetable production.

Potential Contributions

Management techniques to grow and incorporate cover crops on semi-permanent raised beds have been developed and demonstrated for intensive vegetable production systems on commercial sites. The use of cover crops to deplete soil NO_3^--N, and thereby reduce the potential for NO_3^--N contamination of groundwater during winter rains has been demonstrated for a range of soil types. No yield reduction or increase in disease incidence of vegetable crops has yet been found as a result of cover cropping. Cover cropping on semi-permanent beds may reduce cultivation requirements compared to planting and disking on flat ground, and therefore save energy and labor costs. The precise fates of cover crop C and N within the crop ecosystem after incorporation is now being studied. Preliminary evidence suggests that soil microbial biomass and N turnover may increase after successive years of cover cropping. There is anecdotal evidence from local farmers that cover cropping reduces the incidence or severity of some crop diseases (such as corky root) and can reduce nematode populations, which we will pursue in the course of our investigations.

Farmer Adoption

Winter cover cropping is becoming more widespread in the Salinas Valley [of California], as the threat of NO_3^--N leaching to the groundwater becomes more widely known, and the value of building soil fertility through the addition of organic residues becomes more accepted. This project has generated interest in the local agricultural community, evidenced by the good turn out for our field days, and the increasing number of growers now planting winter cover crops on raised beds and using minimum tillage techniques at incorporation.

Operational Recommendations

We recommend the adoption of semi-permanent raised beds, and the use of minimum tillage techniques for cover crop and vegetable residue incorporation. We recommend growing non-leguminous cover crops in two plant rows on the bed tops for approximately 14 weeks from December through March, then flail-mowing before they bolt, and incorporating residues into the top 15 cm of soil on the beds. Vegetable crop planting should be delayed for at least four weeks after incorporation, when there will be less microbial competition for soil N, and the potential for pest problems will be minimized. We recommend soil testing to determine inorganic N pools prior to fertilizer application, which should be timed to coincide with crop N demand.

Farmer Evaluations

All of our cooperators are growing winter cover crops as a result of their participation in this study, and two of them are committing substantially more acreage in addition to our research sites to cover crops. We have received at least 10 requests for cover crop seed, several offers of commercial sites from different growers for future cover crop research, including drip irrigated sites, interest from the largest local fertilizer/farm service company in management techniques to reduce NO_3^--N leaching, and interest from a seed company in becoming a local source for cover crop seed.

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Annual Results

ACE #92-7

Role Of Soil Microbial Biomass And Microbivorous Nematodes In Functioning Of Sustainable Agricultural Systems

Location:
Davis, (Northern) California

Funding Period:
October, 1992 -

Grant Award:
$156,731

Project Coordinators:
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Objectives

1. Compare organic, low-input and conventional farming systems with respect to microbial biomass/activity and nematode numbers and diversity;
2. Determine the relationship between microbial and nematode parameters over the growing season, particularly at times of vetch and stubble incorporation;
3. Determine the relationship between the rate of vetch decomposition and nitrogen availability and microbial and nematode measurements;
4. Compare the ability of soils from low input and organic versus conventional farming systems to withstand stresses associated with agronomic practices.

Abstract of Results

The objectives of this study are to compare organic, low-input and conventional farming systems with respect to microbial biomass/activity and nematode numbers and diversity and compare the ability of soil communities in different farming systems to withstand environmental and anthropogenic stresses. This year,we combined field sampling with laboratory experiments to test specific hypotheses identified in the field. In addition, extensive data analysis was performed on data collected in 1993.

Intensive field sampling of microbial parameters in organic and conventional tomatoes in 1994 supported findings from previous years that microbial biomass carbon and nitrogen are usually significantly higher in organic and low input than conventional tomatoes. Organic corn and tomatoes continue to differ substantially from one another with respect to soil nitrate levels over the growing season. In tomatoes, nitrate levels were usually higher in conventional than organic, whereas nitrate levels in corn were consistently higher in organic and low input than conventional soil. Potentially mineralizable nitrogen was significantly higher in organic and low input than conventional tomatoes; whereas there were no differences among systems in corn.

Analyses performed on data from 1993 indicated that not only does a high microbial biomass correspond to high levels of activity, but the biomass was sometimes metabolically more active in organic than conventional soil. Organic inputs with a carbon/nitrogen ratio well above recommended levels provided sufficient fertility to tomatoes, but not corn, in 1993. This finding suggests the need to rethink, at least for some crops, recommendations for optimum carbon/nitrogen ratios for organic inputs to soils with acclimated microbial communities.

Nematode communities were monitored intensively in 1993 through a tomato growing season in plots managed by conventional and organic farming practices. The temporal dynamics of individual species of bacterial-feeding nematodes differed among species and suggested differing importance of the species in their contribution to nitrogen mineralization in the organically-managed soil. Species with r-selected, colonizer characteristics were most responsive to incorporation of organic matter. Fungal-feeding nematodes were more abundant in conventional than organic plots during periods of organic matter decomposition. Predaceous nematode populations were low in both farming systems while plant-parasitic nematode species reflected the crop sequences in rotations used in each system.

A controlled soil column study was carried out to monitor dynamics of microbial biomass, community structure, and soil carbon and nitrogen pools following cover crop incorporation. Soil from the organic and conventional plots of the related Sustainable Agriculture Farming Systems, SAFS, project (see SARE #89-18) was compared with soil from conventional lettuce plots in Salinas, California (historically receiving far less organic inputs). Preliminary results show larger active fungal populations in the SAFS than Salinas soil, while bacterial numbers are similar in all soils. Soluble carbon was higher in the Salinas than SAFS soils and higher in the organic than conventional SAFS soil. There were fewer total nematodes on all sampling dates in Salinas than SAFS soils. Plant-parasitic nematode numbers were highest in the SAFS conventional soil and very low in either Salinas soil. A well-defined column system containing sand, microorganisms, organic amendment, and nematodes has been designed to test hypotheses regarding the ability of different nematodes to enhance nitrogen mineralization. Preliminary measurements indicate that cumulative nitrogen mineralization occurred at a substantially greater rate in columns containing *Cephalobus persegnis than in columns containing Cruznema tripartitum or Bursilla labiata*.

Potential sources of anthropogenic stresses to soil communities are organic pollutants that are applied or leak into soil. The solvents toluene and trichloroethylene are common contaminants and were used as model compounds to study the effect of pollutant stresses. High levels of toluene or trichloroethylene had no impact on substrate induced respiration, nitrogen mineralization, or plate counts. However, toluene or trichloroethylene cause significant reductions in the rates of ammonium and nitrite oxidation (i.e. nitrification) and were associated with the build-up of high levels of ammonium in soil. A reduction in the metabolic diversity of the soil microbial community were also associated with exposure to trichloroethylene. Trichloroethylene had no apparent effect on nematode community structure, but did substantially reduce total nematode abundance.

Economic Analysis

The goal of this study is to achieve a better understanding of the complex interactions between the availability of plant nutrients and the soil food web, specifically the microbial community and their nematode predators. This study, on its own, does not lend itself to economic analysis. However, findings of this project have contributed to economic analysis presented as part of the larger USDA SARE funded project "A Comparison of Conventional, Low Input and Organic Farming Systems: The Transition Phase and Long Term Viability" (see SARE #89-18). Particularly, nitrogen input requirements are strongly influenced by microbial dynamics. For example, less fertilizer nitrogen was needed in the low input system this year and this is likely due to the build-up of a large pool of organic nitrogen in the microbial biomass and soil organic matter. As this study progresses, we will identify other impacts of microbial and nematode communities on nutrient availability with possible consequences for the economics of different farming systems.

Potential Contributions

Our study has already helped to identify measurements of microbial communities with the greatest yield of information for the work required. There is considerable interest in what simple measurement can be used as an indicator of microbial populations. Potentially mineralizable nitrogen by the anaerobic incubation method (the most simple-to-measure of the microbial parameters) is thought by many to be correlated with microbial biomass carbon. In our study, we found a fairly high degree of correlation between potentially mineralizable nitrogen and microbial biomass; however, not infrequently there were problems with the measurement because of high background levels of mineral nitrogen.

We have found that in organic tomatoes, there was sufficient soil fertility even at very high carbon/nitrogen ratios, and that this was most likely due to the high metabolic activity of large microbial populations in the organic systems. In corn, on the other hand, high carbon/nitrogen ratios clearly present fertility problems. Thus, we may have to re-think recommendations for optimum carbon/nitrogen ratios for organic inputs, at least for some crops.

We are continuing to assess the role of bacterial-feeding nematodes in nutrient cycling and identifying the most important species. Our results may suggest ways to manage soil that favor those species. Certain species may be key indicators of soil health and productivity. In related studies, we hope to learn which beneficial nematode species are most likely to become established when introduced into degraded soils.

Farmer Adoption

The topic of this project is soil biology, which is traditionally treated as a black box, with limited understanding of how to translate knowledge of soil biological processes into specific farming practices. We need to understand the links between microbial communities, their predators, nutrient cycling and crop productivity, and how this translates into the economics of the different farming systems (see SARE #89-18). Certain phenomena that can be managed, such as irrigation and excessive levels of mineral nitrogen, have already been identified as possibly impacting microbial activity and nutrient cycling; however, more analysis of this relationship is needed. We have been in consulation with the farmer advisors associated with this project on the feasibility of utilizing different practices that promote microbial activity. This project is in its first year. By the close of the project, we hope to have a better idea of management practices that can improve fertilty and the resilience of the different farming systems.

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Annual Results

ACE #92-9

Comparative Performance And Farm-Level Function of Conventional and Certified Organic Apple Production Systems In California

Location:
North Central Valley, Central Coast and North Coast regions of California

Funding Period:
July, 1992 -

Grant Award:
$175,224

Project Coordinator:
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Objectives

1. Retain, for multi-year observation, whole systems comparison units of transitional or certified organic and conventional input production as multi-year demonstrations in each of the four important apple production regions in California.
2. Compare potential yield-limiting factors in these systems associated with tree growth and yield, soil characteristics and nutrients, key pests and their associated damage, and natural enemy abundance and response.
3. Demonstrate effectiveness of key management strategies relevant to certified organic production including: codling moth control with pheromone-based mating disruption and microbial sprays; orchard floor management and cover-cropping as a source of soil nutrients and improved structure; and sprayable inorganic or organic compounds and/or cultural substitutions for scab control.
4. Document the economic performance and viability of certified organic production systems or practices in each production region.
5. Disseminate and publish research-based results to the production community, culminating in the publication of the University of California-sponsored *"Guide to Certified Organic Apple Production in California"*.

Abstract of Results

Certified organic apple production has expanded to over 2,000 acres in California, according to certification organization statistics and county agricultural commissioners' records. If this growth trend continues, certified organic apple production could represent as much as ten percent of total state apple acreage in the next five years. However, no specific, field-tested production guidelines exist which could assist growers in converting to certified organic apple management practices, and protocols for pest and disease controls are not nearly as well-defined for organic as for conventional apple production.

In 1994, as part of a continuing USDA/SARE-funded research effort to remedy this lack of information concerning organic production practices, our farm advisor/grower collaborator apple research group completed the fifth production year evaluation of two certified organic production demonstrations (North Central Valley, Central Coast), and completed a four-year study of organic production in the North Coast production region. In addition to these long-term demonstrations, the research group continued and expanded statewide monitoring of synthetic pheromone-based codling moth mating disruption program evaluations, including evaluation of management programs integrating mating disruption with biological (certified organic) and chemical (conventional) controls. In December, 1994 scientific research papers describing aspects of this research were published by all apple research group collaborators in the public-oriented agricultural research journal *California Agriculture*.

Critical management component studies continued in 1994 included: an evaluation of biorational control strategies for secondary pests (rosy apple aphids) in orchards using pheromone-based mating disruption programs for codling moth management in the North Central Valley Region, and comprehensive disease (apple scab) control trials with certified organic spray materials (sulfur, copper, oils, and compost tea) in the North Coast Region, a production area in which disease pressure is most severe in organic management situations.

Two cost of production studies for certified organic apple production in the North and Central Coast regions were completed.

Economic Analysis

Detailed financial budgets have been developed with the assistance of economists Karen Klonsky and Laura Tourte as North Coast research collaborators, and on the Central Coast with the assistance of the project coordinator. Hand labor (45-50%) and pest control (10-15%) comprise the largest costs of production by category in the coastal production regions. Published net returns for certified organic Granny Smith apples were $3,630/acre after two years of low or negative net returns in the North Central Valley. High disease pressure in 1993 limited production to negative or break-even returns on all varieties on the North Coast after positive returns (up to $5,893/acre) in 1991 and 1992. Central Coast returns have not significantly varied from 1991 calculations (approximately $2,000/acre net), however, these newer estimates have not yet been published.

Potential Contributions

Project results to date document the economic performance and feasibility of certified organic apple production in several California locations. In many cases, yields and quality are maintained in organic production systems by careful application and monitoring of alternative technologies. Research-based guidelines for particular climatic regions are being developed to avoid over-generalization. Profitable apple production systems which substitute biologically-based inputs for synthetically-derived pesticides and fertilizers now serve a growing consumer public in California and world markets. Published management guidelines will strengthen grower confidence and reduce economic risks during the process of conversion to these practices in California.

Farmer Adoption

At twenty-two sites statewide, grower collaborators have adopted some or all of project production guidelines. These "focus" blocks have served as the basis for wider dissemination of research-based guidelines for organic production. Over 2,000 acres of certified organic apple production have been documented in 1994 in California by certification organizations and county Agricultural Commissioners listings. Project major participants estimate that approximately 250 growers, farm advisors, pest control advisors, and other agricultural professionals have been directly contacted with seminars, presentations, and short course curricula from the previous project years' activities at the statewide University of California Apple Short Course in Modesto. Major participants held three extension grower meetings (two in Watsonville, one in Brentwood) and disseminated research findings in the journal *California Agriculture*.

The USDA/SARE/ACE California Apple Research Group has been formally legitimized as a statewide source of information on production guidelines for certified organic apples in the different California production regions. Before converting to certified organic management, the project major participants can now recommend consideration by growers of questions regarding climate, varieties, markets, prices, and costs of production for the particular mix of techniques required in the different regions. Growers can now be referred to published agronomic and economic information for particular regional situations, or general guidelines, such as those published in *The Grower* (January, 1995) by Walt Bentley, SARE project major participant, south Central Valley. As such, this project serves directly as a source of information concerning the potential performance to be expected of any apple production system conversion. Widely available published information and more than 100 attendees at three regional 1994 presentations is indicative of widespread exposure to project results in the California apple production community.

New Hypotheses

Some secondary pests (leafminers and mites) are of minor importance in organic production, due to reduction of broad-spectrum insecticide stress. However, other pests, including aphids and leafrollers, have been more abundant in certified organic production orchards, possibly due to lack of abundant, adapted natural enemies in the orchard system. These pests should be monitored and control strategies devised.

The project participants are strengthening hypotheses concerning canopy height, closure, wind exposure, and orchard topography as important factors to consider for codling moth control strategies with pheromone dispensers. Data suggests some trap lures with components other that codlemone are attractive to male codling moth in orchards under mating disruption programs. Meaningful interpretation of comparative catches from conventionally-managed areas when compared to mating disruption sites requires further experience.

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Annual Results

ACE #93-11

Calibration of the Pre-sidedress Soil Nitrate Test to Improve Nitrogen Management on Dairy Farms

Location:

Funding Period:
June, 1993 -

Grant Award:
$50,000

Project Coordinators:
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Objectives

1. Calibrate the pre-sidedress soil nitrate test (PSNT) for use in predicting corn silage yield response to sidedressed N fertilizer on manured and non-manured soils in the Willamette Valley of Oregon.
2. Derive N fertilizer response functions to be used in developing published guidelines for sidedress N fertilization of corn silage.
3. Conduct educational programs to assist dairymen in making more efficient use of N fertilizers and on-farm manure.

Abstract of Results

The Pre-sidedress Soil Nitrate Test (PSNT) is a soil test which measures the nitrate-nitrogen (NO_3-N) concentration in the top 30 cm (1 ft.) of soil when corn (*Zea mays* L.) is at the 5 to 6 leaf stage (1 ft. tall). This in situ assessment of nitrate-nitrogen which becomes available to plants from manure and soil organic matter decomposition (mineralization & nitrification) has been used to successfully predict field corn response to mid-season nitrogen fertilization in Northeast and Mid-Atlantic states. Knowledge about the probability of crop yield response to nitrogen fertilizer is used to avoid excessive application of fertilizer, thereby protecting ground-water water quality.

The relationship between soil test nitrate-nitrogen and crop response to nitrogen fertilizer (calibration) had not been established for corn silage grown in the Pacific Northwest. We calibrated the PSNT on Western Oregon dairy farms to encourage efficient use of nitrogen from manure and fertilizers. Twenty-six field experiments were conducted on 18 farms during the 1993 and 1994 growing seasons. Replicated treatments of 0 or 200 kg urea-N/ha^{-1} were applied as a sidedressing at the V5 growth stage (5 leaves) of silage corn grown on soils differing in manure application history. Silage yield, crude protein, and removal of nitrogen by the crop were increased by fertilizer application at only a few sites.

At-planting and post-harvest concentrations of NO_3-N to a depth of 150 cm (5 ft.) showed that nitrogen applied as manure or fertilizer was often in excess of crop requirements. A PSNT "critical value" of 21 mg NO_3-N kg^{-1} was found to distinguish between nitrogen-responsive (nitrogen deficient) and non-responsive fields. We showed that the concentration of nitrate-nitrogen in the lower 15 cm of corn stalks at harvest was highly correlated with the PSNT and could also be used to distinguish responsive from non-responsive sites.

This project provides dairy producers in the Pacific Northwest with two tools that they can use to improve nitrogen management. Growers can use the PSNT to "predict" the need for mid-season supplemental nitrogen and/or use the Corn Stalk Nitrate concentrations as a "report card" method of identifying fields where nitrogen was supplied in excess of crop needs. Educational efforts are underway to widely disseminate this information to dairy producers.

Economic Analysis

Data suggest that many dairy producers can realize substantial savings by reducing or eliminating nitrogen fertilizer purchases. We intend to use the data collected to estimate dollar cost savings.

Potential Contributions

This project demonstrates that dairy producers can reduce production costs, protect water quality and maintain corn silage yield by using PSNT and Corn Stalk Nitrate tests to refine management of nitrogen applied as manure or commercial fertilizer. The most immediate impact will be the financial savings realized by the farmers. Society will benefit from grower adoption of this technology because it protects groundwater quality. By minimizing nitrate-nitrogen remaining in the soil profile at harvest, growers will be able to reduce over-winter leaching loss of nitrate.

Farmer Adoption

We expect that most dairy producers in Western Oregon will eliminate or sharply curtail the use of nitrogen fertilizers on corn silage once these results have been widely disseminated. Reductions of nitrogen fertilizer application from 180 to 30 kg N ha^{-1} are highly probable.

We recommend that dairy producers refrain from applying more than 30 kg N ha^{-1} when planting corn for silage. Growers should take a representative soil sample from the top 30 cm of soil when corn is in the 5 leaf stage and have it analyzed for NO_3-N. No additional nitrogen from fertilizer or manure would be recommended if the soil test reveals a NO_3-N concentration greater than 21 mg NO_3-N kg^{-1} soil.

New Hypotheses

We are examining the feasibility of a pre-plant soil test based upon absorbance of ultraviolet light (UV205 nm) passed through a 0.01 M $NaHCO_3$ soil extract. If this soil test can be refined and calibrated it would offer growers and even earlier determination of the need for supplemental nitrogen.

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Annual Results

SARE #92-31

Grazing Strategies for Sustainable Ranching Systems in Western Semi-Arid Zones

Location:
Grant County, Oregon

Funding Period:
October, 1992 -

Grant Award:
$237,738

Project Coordinator:
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Objectives

1. To collect biological, hydrological, management, and economic baseline data for whole ranch operations that use summer season long (no haying), summer short duration rotation (with haying) and fall short duration (following haying) systems (incorporating a broad range of grazing intensity and distributional controls) designed to enhance riparian and closely related habitats.
2. To monitor performance of variations in management (moderate to heavy summer season grazing versus summer short duration rotation with haying and fall short duration following haying) of the identified whole ranch systems for two full growing seasons;
3. To determine the impact of alternative grazing strategies on ranch and livestock performance (production, whole ranch profitability, long term financial stability, and risk), on riparian zone and adjacent irrigated meadows, wildlife habitat, and resident salmonid habitat;
4. To identify constraints on adoption of "best management practices" for ecologically compatible grazing strategies in riparian zones and adjacent irrigated meadows which may be resolved through either research, user education, and/or through management and policy changes;
5. To develop guidelines for the design and implementation of alternative whole ranch grazing system, grazing intensity, and distributional control strategies (that are economically viable and appear to be compatible with ecologically sound riparian and adjacent irrigated meadows); and
6. To prepare relevant audiovisuals supporting user-oriented publications, and conduct on- and off-site demonstrations and educational programs on "best management practices" to encourage transfer to viable intensive grazing system technologies.

Abstract of Results

The study area is located in Grant County, Oregon. Twelve experimental units were identified in the study area based upon 1) site similarity, and 2) management intensities which were in place for at least five consecutive years. The three treatments represent a primarily herbaceous vegetation cover currently managed under a summer season-long grazing system; a primarily discontinuous woody plant cover near the riparian zones currently managed under a summer short-duration grazing system; and a primarily continuous woody plant cover near riparian zones currently managed under a fall short-duration grazing system. Four replicates of each treatment were identified.

Economic information was collected by personal interview for each treatment and replicate as well as for the whole ranch. These return and cost data are currently analyzed and will be used to estimate the effect of alternative vegetation covers and grazing strategies.

Forage quality samples were collected in 1993 and 1994, with analysis completed for the 1993 samples. Crude protein of hay samples varied from 4.98 to 6.69 percent on dry matter basis. In vitro dry matter digestibility varied from 42.3 to 56.7 percent.

Field data for classifying the streams using Rosgen's stream classification system have been collected for two summers. Measurement to depth of water table were also collected. These measurements will be used to examine if a relationship can be established between width/depth ratios and entrenchment ratios.

It was found that water table movement in response to irrigation manipulations occurred within 24 hours. The wells closest to the ditch and the furthest from the creek responded first, whereas the wells located at creekside showed little sensitivity. This phenomenon indicates the importance of irrigation in maintaining the riparian status of these meadows. The impact of irrigation on stream parameters, primarily stream temperatures, is currently being researched.

In 1993 and 1994, we detected 7,343 birds representing 63 species. Total bird abundance and species richness were greater along the continuous woody vegetation transects than along herbaceous vegetation transects. Of 23 bird species with more than 20 total individual detections, ten species exhibited significant associations with either continuous woody vegetation or herbaceous vegetation.

In 1994, four small mammal species were captured: deer mice, montane vole, western jumping mouse, and vagrant shrew. Montane voles were found to be the dominant species in most grids. Deer mice were poorly represented in all but one grid with discontinuous woody vegetation.

Eight presentations and papers have already been completed on the preliminary findings of the study, and two additional papers and presentations are in process. The audience reached included ranchers, public resource managers, administrators, and researchers.

Economic Analysis

All cooperating ranchers have a cow-yearling type of operation. Herd sizes range from 320 cows to 1,400 cows, and returns to capital, management and land vary between about $80 per cow and $286 per cow. To what extent, if any, these variations in costs are determined by differences in grazing systems has not yet been determined. Detailed financial budgets, including inputs, outputs, performance ratios, etc. are currently being developed from survey results, ranch observations, and other sources.

Potential Contributions

Documenting wildlife response to intermediate grazing strategies may identify management alternatives that are more sustainable from a wildlife habitat perspective, and may in turn permit more constructive coalitions between agricultural industry and environmental groups.

Understanding hydrology will allow better projection of results from alternative water management practices.

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Annual Results

ACE #93-12

Range Monitoring in the Upper Stony Creek Watershed

Location:
Tehama County,
Northern California

Funding Period:
January, 1994 -

Grant Award:
$40,000

Project Coordinator:
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Objectives

1. Document the effect of grazing systems and resulting stocking densities on annual rangeland ecology by monitoring changes over time in:
   a. Ground cover, canopy cover, soil bulk density, target plant density, residual dry matter, grazing intensity, infiltration rates and interrill erosion.
2. Determine the impact of grazing systems and resulting stocking densities on the riparian profile and vegetation by monitoring changes over time in:
   a. Streambank vegetation density and canopy cover.
   b. Elevation transects of riparian above and below check dams.
3). To develop, demonstrate, and achieve rancher adoption of procedures by which they can and will monitor progress or lack of progress toward meeting their production and landscape goals.

Abstract of Results

This detailed monitoring will not only provide data on the impacts of land management practices in the watershed, but also provide data to validate or indicate the inadequacies of simpler level of monitoring. The second level of monitoring is in fact simple, practical, and economical so that landowners can take on the task of monitoring their own rangeland.

The primary focus of this project is to develop, demonstrate, and achieve rancher adoption of procedures by which they can and will monitor progress or lack of progress toward meeting their landscape goals on the watershed.

Objectives 1 and 2. Detailed monitoring is being conducted at sites on two ranches in the watershed. At each site cattle grazing impacts are being investigated with two replications of three grazing regimes: a high-intensity-short duration treatment, a no grazing treatment, and a traditional seasonal grazing regime. Grazing treatments have been fenced and baseline data has been collected. Range plant cover, canopy cover, target plant density, soil crusting characteristics were determined for each treatment using the Savory dart-throw method. Residual dry matter and soil bulk density have also been determined for each treatment. This data will be collected each year and compared between treatment and years.

Detailed monitoring of the riparian profiles has been completed for the past three years. During these years all treatments have been rested. (No livestock grazing has occurred.) Riparian vegetation in all treatments has recovered well as evident by the photo plots in each treatment. Grazing treatments will be applied to this site in the Spring.

Objective 3. In cooperation with six other natural resource/livestock advisors in Northern California we have developed a publication for ranchers on how to monitor. This publication has evolved into a two-level approach. Level 1 instructs ranchers on how to monitor range sites with a camera. This level includes a videotape. Level 1 has recently been published. Level 2 is in preliminary draft form. Monitoring data from objective 1 and 2 of this project is being used to develop the methodology for a chapter on monitoring vegetation and ground cover. During a monitoring workshop I conducted with 15 landowners in the Spring 1994 I tested vegetation monitoring techniques and have revised them accordingly.

During this monitoring workshop, I was able to encourage ranchers to consider photo monitoring by demonstrating a rocket camera. I fired an astrocam, a rocket with a little camera attached to it over the rangeland. The rocket was to take an aerial photo of the landscape, although the unit malfunctioned, the excitement this created among the ranchers was tremendous. They were eager to learn more about techniques they might use to monitor their rangeland. This winter and spring I am providing each landowner in the watershed with a how to monitor manual and a disposable camera. Landowners will be encouraged to share their photo plots.

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Final Results

SARE #88-1

Evaluation and Design of Low-input Sustainable Vegetable/Small Grain and Small Fruit Systems of Western Oregon and Washington

Location:
Western Oregon and Western Washington

Funding Period:
October, 1988 - April, 1994

Grant Award:
$464,105

Project Coordinators:
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Objectives

1. Develop a preliminary compendia of information and resources of existing sustainable production methods for dissemination in a Resource Guide and newsletter.
2. Conduct educational activities on sustainable agriculture that will provide opportunities for dialogue and information transfer among producers, researchers, extension personnel, private industry, and consumers.
3. Determine the range and extent of alternative vegetable and small fruit systems in relation to conventional systems.
4. Examine whole farm systems from an ecological and multi-disciplinary perspective to provide a basis for future research to design efficient, economical, and more sustainable systems.
5. To develop and evaluate new mechanisms of involving farmers and scientists as partners in designing, conducting and evaluating on-farm demonstrations of alternative cropping systems.
6. To facilitate communication and understanding among farmers, scientists, and other interest groups on alternative strategies for managing cropping systems in western Washington and Oregon.

Abstract

The project was initiated in 1988 and completed in 1994. During Phase I (1988-1991) extensive surveys, whole farm case studies and extension activities were conducted in relation to sustainable agriculture. *A 236-page Resource Guide for sustainable agriculture was produced for farmers and ag. professionals* to assist them in locating and accessing existing sources of information. A quarterly newsletter was initiated and continues beyond the life of this project with a circulation of 2,000 plus. Team members have developed and extensively used innovative methods (e.g. focus sessions and interactive conferences and workshops) to involve diverse groups in extension activities, on-farm and station research design and implementation, and involvement in the land grant system in relation to promoting sustainable agriculture. The highly successful *Farming for Profit and Stewardship* has been a highly visible and important vehicle for sustainable agriculture in the Pacific Northwest. Surveys and in-depth studies have addressed marketing issues of organic produce, economic performance of alternative systems, extent and adoption of more sustainable practices, and classification of growers in relation to sustainability according to farm structure and farming practices.

Whole farm case studies were conducted over a three year period by an interdisciplinary team that included farm visits by biological and social scientists. Findings of these studies include that: generally labor costs are higher on organic farms; IPM is used very little on farms due to complexity of management and labor costs; Pacific Northwest farmers are difficult to classify into sustainability rankings; and large farms are more likely to use crop rotations and minimum tillage whereas small farms are more likely to substitute labor for chemical inputs.

During Phase II there was: continuation of extensive educational/co-learning activities; emphasis on institutionalization of sustainable agriculture in the land grant system and main stream agriculture; and establishment of on-farm research and demonstration projects. In both Western WA and OR active on-farm research programs are in place with emphasis on cover crops for protecting groundwater and promoting soil quality, and formal sustainable agriculture programs have begun in Oregon and Washington.

Through station and on-farm research cover crop species and management systems have been identified and characterized for nitrogen accumulation and availability.

A major accomplishment of the overall project has been to decrease the polarization among diverse groups and there appears to be an emerging consensus for the agricultural and environmental/consumer groups to work together to promote an agriculture that is environmentally sound, profitable and has positive social impacts. Written products have included Extension Fact Sheets, how-to guides for focus sessions and whole-farm case studies, refereed journal articles, resource guides, Experiment Station Technical Reports, proceedings, book chapters, and numerous miscellaneous reports.

Potential Contributions

Through organized events such as conferences, workshops, lectures and written communications (newsletters, reports, etc.) the project has made significant progress in increasing the level of awareness on sustainable agriculture issues in the Pacific Northwest.

Socio-economic analysis has identified issues related to: off-farm purchased inputs; labor availability and management; computer applications to management; development of value-added opportunities; and increased public interest in food, environmental, and agricultural policies.

The process of conducting the **Whole Farm Case Study** has been effective in developing a better understanding of vegetable and small fruit systems and in documenting strengths and weaknesses of alternative systems. Unexpected innovations of farmers were discovered through this study, which have been shared with other farmers and scientists throughout the region and in several areas of the country..

The **Minto-Brown Island Park** project has been very successful in coordinating field days with farmers to demonstrate alternative management practices and also serves to provide educational opportunities for school groups in the Salem, Oregon area. Because of its unique location near a major urban center it has been a real opportunity to provide information to the urban sector that shows a proactive approach toward environmental and resource management issues by the diverse members of the agricultural community.

This project has had a **major impact on the land grant systems** of Oregon and Washington. It resulted in interdisciplinary activity among extension and research personnel in collaboration with farmers which had not really previously happened at these institutions. Because of the activities of the Team we have earned a level of legitimacy for sustainable agriculture that did not exist five years ago. The just completed study ***(Land Grant University Agricultural and Natural Resources Research: Perceptions and Influence of External Interest Groups)*** investigates the role of university personnel, established organizations (commodity and ag. industry), and consumer/environmental organizations, in affecting research and extension activities in relation to sustainable agriculture at OSU, WSU, and University of Idaho

Farmer Adoption

Interactive and partnership approaches for farmer forums, focus groups, farmer/scientist focus sessions, and conferences have been effective in sharing and communicating innovative practices and experiences among farmers, interest groups, and university and government agency personnel. Involvement of farmers in identifying present constraints and opportunities for alternative systems has been important in setting research priorities that are more likely to have practical applications.

We have seen a dramatic increase in the use of cover crops in Western Oregon and Washington in the past two years. Farmers are using them to: control erosion; capture excess nitrogen and prevent its potential to pollute ground and surface water and for use by subsequent crops; and to improve soil tilth.

There has been a change in how scientists and growers solve problems. It is now a much more interactive approach and farmers' ideas for solving problems or designing research are much more likely to be a part of the process.

Farmer Comments

"Farmers are always fooling around with their own experiments, but they don't get data that other farmers can use. Or maybe they get a false perception of what they did. This project is set up to get better information we [farmers] can really use".

— Keith Grover, Salem, OR, cooperating farmer for on-farm research

"The focus group has broadened my insights to some of the problems we have to face in the future if agriculture is to remain in the Skagit Valley and some other urban areas in western Washington."

— Skagit County [WA] Cropping Strategies and Water Quality Focus Group member

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Final Results

SARE #89-14

Low Input Legume/Cereal Rotations for the Northern Great Plains-Intermountain Region

Location:
Gallatin, Pondera, Dawson, Chouteau, Rosebud, and McCone Counties, Montana

Funding Period:
June, 1989 - April, 1994

Grant Award:
$162,000

Project Coordinator:
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Objectives

1. To develop dryland legume green manure/cereal rotations using prescribed amounts of water.
2. To measure water-use-efficiency of legumes in terms of biomass and N-fixation.
3. To develop a dual-use system of one-year hay and green manure with irrigation.
4. To determine the effects of green manure on soil N mineralization and nitrate distribution.
5. To adapt legume species to agro-climatic zones in the region.
6. To conduct on-farm, field-scale demonstrations of legume/cereal rotations.
7. To teach producers-at-large and agency personnel how to adapt legume/cereal rotations.

Abstract of Results

This was a comprehensive, multi-state research demonstration and extension project with SARE goals. Activities were designed by the participants, including farmers, to provide data needed to devise cropping systems which allow farmers to reduce purchased inputs, diversify crops, and stabilize income while maintaining profitability and enhancing the environment. Research on dryland systems focused on legume green manure as the nitrogen source for small grains under limited water constraints and annual legumes as alternate cash crops.

Research on irrigated systems focused on dual use of legumes for hay (income stability) and re-growth for green manure as the nitrogen source for ensuing small grain crops as well as a non-chemical weed control derived from cutting management. It is gratifying to report that all seven above-stated objectives were achieved, and that their combined results have had a significant, positive impact on regional agriculture.

Our results show that the dryland water resource can be monitored and managed to allow the growth of a green manure crop in lieu of summer fallow while maintaining about the same amount of water for the ensuing small grain crop. Our data shows that annual legumes do vary in water-use-efficiency, both in terms of biomass production and nitrogen-fixation. Austrian winter pea was superior to four other species studied for water-use-efficiency.

Our research on irrigated systems developed a successful dual-use system in which Berseem clover and annual alfalfa are cut twice to yield 2.5 to 3.0 tons of hay/acre with full re-growth used as a green manure to meet the nitrogen needs of the next year's barley crop. The two hay cuttings and/or inclusion of an oat nurse crop constitute non-chemical weed control.

Our data show that legumes took up existing mineralized soil nitrogen, augmented that with nitrogen-fixation and, after incorporation as green manures, mineralization of their nitrogen was dependent on rainfall and/or available soil water during the warm season. As a result, in some instances small amounts of nitrogen were mineralized the first year with greater amounts appearing the second and third years after incorporation.

Over 175 lines representing a total of 36 annual legume species were evaluated for adaptation to the various environments in the region. More than fifty on-farm field-scale demonstrations of legume/cereal rotations were completed during the project. In addition to the participants, hundreds, if not a few thousand, of farmers-at-large and scores of agency personnel were taught the results of our work through our dissemination activities.

Economic Analysis

The results of the rotational trials are somewhat diverse because of the variability in climatic conditions, soils, and rotations used on these farms. In general, the sustainable rotations (those which had legumes in them) did reasonably well. From an economic point of view the legume rotations were deemed successful if they produced the basic cash crops (wheat and barley) at a cost which was reasonably close to the cost of the historical practices used on these farms. The full benefits of the rotational changes will not show up in the period of a single cropping cycle. Detailed economic analysis on a per site basis are available.

Potential Contributions

Precipitation use: Annually, three to four million acre-feet of water that now contributes saline seep formation, leaching of nitrates to ground water by percolating below the root zone, runs off the fields or evaporates would be used to grow green manure/cover crops or alternate cash crops.

Annually, about 120,000 tons of synthetic N fertilizer costing about $24 million ($5 to $15 per acre) would be replaced by legume N which would be placed more ideally in the soil, more gradually released for plant uptake and less subject to leaching or becoming a ground water pollutant.

Several hundred thousand to a few million acres damaged annually by erosion, primarily by wind but, also, some by water, would have the erosion damage reduced to tolerable levels. A minimum 5 tons/acre/year reduction is estimated.

Annually, 75,000 to 150,000 tons of seed for green manure, cover and alternate cash crops would be required. Much of this could be produced on-farm for plant back but, a significant portion would be supplied by the seed trade industry. This would be a $50 million industry in this region.

Tractor fuel bills would be reduced from 50 to 80 percent. Estimate to be from $5000 to $50,000 per farm, depending on size.

A few to several hundred farms in the higher rainfall areas would derive the above benefits while maintaining income stability by adopting dual-use legumes (hay and green manure) in their rotations. Barley producers in these areas would achieve maximum economic yield without the use of commercial N fertilizer.

Farmer Adoption

It is estimated that about 2,000 farms have adopted an annual legume in lieu of summer fallow grown in rotation with small grains on an average of 50 acres per farm.

Operational recommendations include:

- Obtain over 150 climatic and soil attributes of their farm from MAPS Mailbox computer program.
- Accurately monitor stored soil water and precipitation on their farm throughout the year.
- Begin adoption of the flexible green manure cropping system by planting an annual legume in lieu of summer fallow on about 100 acres (10% of fallow ground) to learn how and to obtain site specific evaluation.
- Stop using cultivated summer fallow (Black fallow).
- Stop using chem-fallow (Brown fallow).
- Plant about 50 acres of a legume cash seed crop or other alternate cash crop to learn how to grow, harvest, clean, store, and market these crops.
- Diversify cropping pattern to include one or more specialty crops on 10% to 20% of cropland.
- Integrate a livestock (cattle, sheep, or hogs) enterprise with the cash crop enterprises.

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Final Results

SARE #89-17

Silvopastoral Options For Fruit Growers

Location:
Prosser, Washington and Latah County, Idaho.

Funding Period:
June, 1989 - April, 1994

Grant Award:
$65,641

Project Coordinator:
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Objectives

1. Compare income potential of traditional orchard management to combined orchard/sheep production.
2. Identify management advantages and constraints (time, investment, logistics) to a joint fruit and sheep production system.
3. Measure interactions of pasture understory and fruit production, tree phenology, soil compaction, and soil nitrogen in the orchard.
4. Determine the level of browsing which trees can sustain without affecting fruit production, if complete control of browsing cannot be reasonably achieved.
5. Develop and test training methods and devices for their potential to reduce browsing damage by sheep.
6. Determine potential toxicity to sheep from use of required pesticides in grazed cherry orchards and from unlimited ingestion of cherry foliage.
7. Formulate sweet cherry orchard/pasture management guidelines and stocking rates for this region, and as a model for other fruits and regions.
8. Disseminate information about orchard grazing opportunities and constraints by publication in grower journals, extension publications and scientific journals, and through field days for interested groups, and by actively involving extension personnel in the research.

Abstract of Results

Traditional orchard understory management (mowing and herbicide use) was compared with a variety of orchard grazing strategies using sheep. Over the five years of the study, we determined that sheep (and probably other grazers) can be successfully grazed in a mature orchard, reducing the need to mow and spray in the orchard and providing an additional source of revenue. Management complexity increases such that reduced chemical inputs may be offset by additional labor inputs.

A model was developed that summarizes silvopastoral options for orchardists. Economic analyses are not complete, but economic constraints do not appear insurmountable.

Depending on the type of orchard and how intensely grazing animals are managed, some browsing of fruit trees occurs. Browsing can be contained below the threshold of economic damage. However, even if economic damage does not occur, browsing may be unacceptable to some producers. We must point out that the potential hazards of residues from chemicals used on tree fruits to food animals have not been identified and must be considered for any orchard grazing practice.

Economic Analysis

Data collected from the major research site during the project are presently being analyzed using farm budgeting and internal rate of return procedures. We expect the first results of these analyses by January of 1996.

Potential Contributions and Practical Applications

The single most substantive benefit of this project was to create awareness of alternative orchard management practices. A number of other orchardists have adopted this idea and modified it to their own needs. None that we know of have made a 100% conversion to using livestock to manage the orchard understory, but livestock have been added to their management strategies.

All of the grazed orchards experienced a reduced investment of labor, machinery and fossil fuels associated with orchard mowing. Those that had used herbicides were able to reduce labor and chemical inputs to vegetation management. All of these would contribute to reduced ground water and air pollution and perhaps to chemical residues in fruit. These changes were to some degree offset by the resources invested in establishing a seeded forage understory where this was done, and by the electric energy used to power fence systems. Labor inputs often changed, but may not have been reduced overall. Involving family members in alternative enterprises may have significant intangible benefits to family well being (such as shared 4-H involvement). The net effect of changes in income stream has not been derived yet, but diversifying sources of income and distributing labor demands more evenly over the year are evident advantages. An added benefit of significance to some is that sheep consume windfall fruit that attracts yellow jackets and helps reduce this hazard to orchard workers.

Farmer Adoption

This technique is still in the development stage and it is too early to try to generalize changes in practice that have occurred on any major scale as a result of this work.

Orchardists interested in diversifying their operation should consider grazing or housing livestock in the orchard understory.

It is not necessary to own livestock, leasing grazing privileges, barter, or even no charge offering of forage may still be advantageous, without the capital and investment in new knowledge needed to add an additional enterprise.

Recently shed leaves from fruit trees are a nutritious and palatable forage that animals will readily consume, clearing the orchard of debris that may harbor pests and diseases. Fall grazing is a good way to begin gradually experimenting with orchard grazing.

Secure perimeter fencing and a non-orchard holding area are essential. Electric fencing is satisfactory if livestock have been trained to an electric fence.

Even among a given species and breed, behavior among different groups of livestock varies and careful monitoring of livestock behavior in the orchard is needed to forestall any potential problems (one group of sheep learned to unplug the electric fence, individual animals may damage tree bark etc...).

Livestock should be removed during irrigation and for the reentry period of any agricultural chemicals used in the orchard.

Producer Involvement

We did not keep track of numbers in attendance at presentations, but estimate the total number of different producers and land management advisors who have learned about the project from these presentations to be over 2000. In addition, press coverage and word of mouth resulted in continual inquiries about the project from throughout the U.S. and Canada as well as a number of overseas inquiries. A number of local and visiting producers have visited both farms and the investigators have done some on-farm consultation with interested producers as well.

Areas Needing Additional Study

There are many different orchard crops that might be produced in a silvopastoral setting. In addition, there are many different production systems used for production of each crop. The chemical inputs of each system create unique questions about the safety of food animal production in each setting. Even organic producers use a variety of crop amendments whose impact on livestock are largely unknown. The question of potential impacts of accumulated chemical residues on forages and livestock is a critical one that must be considered for each potential combination of crop, livestock and production system. The trend towards integrated pest management and reduced chemical inputs creates additional opportunities for integrating crop and livestock production.

Another area needing more work before crop and livestock production can be optimally integrated is the degree to which livestock feeding behavior can be practically modified.

How a producer's identity affects choices of production technologies is a more important question than it might first appear. We must be able to effectively track the evolving motivations of non-traditional land owners and operators if we are to optimally realize the private and public benefits of agriculture and natural resource management.

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Western Region

Sustainable Agriculture Research and Education

Utah State University
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Final Results

SARE #89-18

A Comparison of Conventional, Low Input and Organic Farming Systems: The Transition Phase and Long Term Viability

Location:
Davis, California

Funding Period:
January, 1989 to March, 1995

Grant Award:
$600,000

Project Coordinator:
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Objectives

1. Compare four farming systems, with differing levels of dependence on external resources over a twelve year period, with respect to:
   — Abundance and diversity of weed, pathogen, arthropod and nematode populations.
   — Changes in soil biology, physics, chemistry, and water relations.
   — Crop growth, yield and quality as influenced by different pest management, agronomic and rotational schemes.
   — Economic viability
2. Evaluate existing and/or novel sustainable and organic farming tactics
3. Distribute and facilitate adoption of information generated by this project to all interested parties as it becomes available.

Abstract of Results

At the halfway point of a twelve-year multidisciplinary farming systems experiment comparing organic, low-input and conventional farming systems, yields for safflower, beans and wheat have stabilized across all systems and are equivalent, while corn and tomato yields continue to fluctuate.

Low-input corn yields have consistently outperformed conventional and organic yields for the last three years and the low-input corn appears to have the most efficient nitrogen uptake and use, while organic corn yields vary based on seasonal nitrogen availability.

Tomato yields have fluctuated considerably between years and systems, and the conventional tomatoes continue to outyield the low-input and organic ones, despite the use of transplants in the latter two systems.

Nitrogen availability appears to be less of a driving factor in the yield determination of low-input and organic tomatoes than it is in corn, although type and content of organic inputs can substantially affect other factors such as nitrogen leaching potential, and crop use and efficiency.

The transition period was clearly important for the soil microbial community. It took at least three years for microbial populations in the organic and low-input systems to reach consistently higher levels of biomass, and activity, presumably making them better able to turn over organic material and generate nutrients for the crops, than populations in the conventional systems. It was evident that rapid turnover of organic forms of nutrients by microbial populations in organic and low-input tomato plots in 1993 led to high tomato yields even under nitrogen immobilization conditions.

Beneficial nematodes have been consistently greater in the organic and low-input plots in the last few years, most likely as a result of cumulative additions of organic matter. Insect and pathogen pests have fluctuated primarily by season, crop and system, and are much more weather dependent than system driven.

Weed pressure has also fluctuated considerably over the six years, showing more significant seasonal than system differences. The determining factor for variation in weed pressure is type of chemical and mechanical control. Shifts in weed species have occurred in the systems, most likely as a result of differences in herbicides used and longer fallow periods in the conventional systems, leading to greater invasion of perennial species in the conventional plots, and an increase in grass species in the organic and low-input plots.

The conventional systems continue to return a higher profit than the organic or low-input systems (unless organic returns are calculated based on premium prices), although the year to year variability of costs and returns is very high in all four systems.

Economic Analysis

The design of a farm production system must take into account the costs of the inputs into the system and the resulting value of the output. Conventional agriculture has traditionally placed the greatest importance on yield maximization while alternative agriculture has emphasized minimizing inputs, and in particular, nonrenewable resources.

Averaged over the first five years of the project, the total production costs for all four systems are remarkably similar. These averages are misleading, however, because year to year comparisons demonstrate that the costs of low-input and organic systems can be either higher or lower than an analogous conventional system depending on the cover crop species selected, the number of operations used for ground preparation, method of cover crop incorporation, and the degree of substitution of hand labor for pesticides and fossil fuels. The reduced inputs in 1989 and 1991 succeeded in reducing relative costs but resulted in poor yields and lower profits for the low-input and organic systems compared to the conventional systems. Switching to transplanted tomatoes from direct seeded in 1992 onward substantially increased the cost of the low-input and organic systems with mixed success in yields.

Averaging over all crops within each system shows the conventional two-year system with the highest average gross income, the second lowest average cost and the highest profit of all of the systems. The conventional four-year system had the lowest costs as well as the second highest net returns and third highest gross returns when no price premiums were included for the organic crops. The low-input system has higher average costs than the conventional systems because of the difference in hand hoeing costs and the use of transplanted tomatoes. The organic systems had the lowest gross returns and the highest costs of all the systems resulting in a net loss of $2/acre over the first five years. However, when premium prices were included for the organic crops, the gross returns were only slightly behind the conventional two-year system and significantly higher than the other two systems.

Potential Contributions

Since tomatoes are the principle cash crop in all of the systems, it is imperative that profitability be maximized for this crop, especially in the low-input and organic systems. One practice that originally showed promise for increasing yields and profits in the low-input and organic tomatoes is transplanting. Extraneous circumstances in 1993 and 1994, however, confounded tomato yield data making conclusions about the transplants premature.

It has been difficult to find a winter cash crop in the low-input and organic system that will meet the agronomic and economic needs of the systems. Previous crops tested have all been economic losses, but in 1993 and 1994 the oats/vetch in this niche provided profits for the whole farm. The oats/vetch mixture may also help to reduce nitrate leaching following corn, as yield data has shown that the oats respond well to residual soil nitrate and may act as a "catch crop".

Soil and tissue fertility data from the corn and tomatoes suggest that low-input farming has good potential to reduce synthetic fertilizer inputs and costs.

Farmer Adoption

Changes observed and reported include greater interest in cover crops, legumes and crop rotations; increased organic acreage in field crops; increased monitoring by growers of water use/efficiency, pest thresholds and soil and crop nitrogen requirements; and heightened interest in a more holistic view of soil health. Agricultural equipment dealers have also begun demonstrating more of an interest in specialized equipment, specifically for tillage and non-chemical weed management. Some growers have specifically reported using transplanted tomatoes in organic production as a direct result of this work.

Operational Recommendations

Results from the first six years have provided information on transition strategies that might benefit growers as they decide to shift to reduced chemical input farming. Foremost is that a grower should plan a transition to low-input or organic farming based on a workable crop rotation, equipment realities and management skills. There may very well be a delay of several years before the soil microbial populations are able to optimally provide plant nutrients from organic inputs and fertilization strategies may want to reflect this delay. Good soil and cover crop management is critical at all times; a multifaceted approach to nitrogen fertility including cover crops, manures, composts, starters and foliars is probably the best strategy for reducing risk of nitrogen deficiencies. Results indicate that direct seeded tomatoes may not be the best crop to use in the early stages of a transition to low-input or organic farming systems; organic safflower, beans and corn all had higher yields than tomatoes in the early years of the transition. A successful transition strategy could include a slow reduction of inputs rather than an immediate shift to entirely organic inputs.

Some general recommendations are to begin incorporating residues, as opposed to burning, and growing green manure crops to start building high microbial biomass and active soil organic matter. Use of no-till or minimum till, whenever possible, would also build soil organic matter. The use of transplanted tomatoes in cover crop systems has high potential, as it allows for increased biomass and nitrogen fixation of the preceding cover crop. The use of herbicides is not warranted in many instances, as cultivation is frequently a cost effective alternative. Field weed history should be monitored regularly and herbicides used only as needed.

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Final Results

SARE #91-22

Brassica Utilization in Sugarbeet Rotations For Biological Control of Cyst Nematode

Location:
Wyoming

Funding Period:
October, 1991 - December, 1994

Grant Award:
$147,000

Project Coordinator:
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Objectives

1. Determine the effects of various cultural practices on biological control of sugar beet cyst nematodes and demonstrate the use of nematode-resistant brassicas in sugar beet rotations.
2. Determine costs, returns and benefits of practices utilizing nematode-resistant brassicas for potential use in sugar beet rotations.
3. Develop and deliver educational information and materials for sugar beet producers and conduct in-service training for Cooperative Extension personnel.

Abstract of Results

Trap-crops radish and mustard, introduced into sugar beet rotations, as alternatives to nematicides, were evaluated during 1992-94.

Trap-crop radishes were most effective in reducing the Sugar Beet (Cyst) Nematode population and increasing sugar beet yields the following year when following malt barley in the rotation. Soil populations of the Sugar Beet Nematode were reduced 54 to 75 percent over a two-and-a-half month period, resulting in a 3.91 ton/acre increase in sugar beet yield. When radishes followed removal of silage corn the increase in sugar beet yield was 2.60 tons/acre. Radishes were less effective following dry beans, compared to barley and corn, because of the later planting date and the very high Sugar Beet Nematode population on the field studied. Soil populations of the pest were reduced on all five fields where radishes were planted.

Trap-crop radishes had a more positive effect on sugar beet yields than the full-label rate of chemical pesticide aldicarb in two of five cooperator tests. In two tests neither radishes nor aldicarb had a significant effect on yield. There appears to be no additive effect of radishes and aldicarb on Sugar Beet Nematode population reduction.

Estimated increase in sugar beet yield necessary to pay the cost of growing trap crops was 2.0 tons/acre; therefore, planting radishes following malt barley and silage corn in 1992 was a profitable operation. On two fields in 1994 (radishes in 1993), sugar beet yields were low due to environmental and other reasons, masking any effect of radish use.

Based on average lamb performance in the five grazing trials conducted and the five-year average lamb price in October, *the value of lamb gain/acre more than offset the cost of producing and grazing trap-crops radish and mustard. Both species are readily grazed by lambs in the fall and provide a high-quality forage, allowing value to be added before marketing.* Grazing did not negate the Sugar Beet Nematode reduction potential of radish because grazing was after soil temperatures had decreased below the minimum for nematode activity.

In summary, the nematode-trapping varieties of radish and mustard, which are currently used in Europe as a replacement for nematicides, are effective and profitable in the sugar beet rotation of Wyoming in which malt barley is grown. Trap-crop radish can be grown in lieu of aldicarb, provided that the initial population of Sugar Beet Nematode does not exceed ten to twelve eggs and/or juveniles per cm3 of soil. The radish crop can be utilized as fall grazing to improve returns without sacrificing Sugar Beet Nematode control. Crop rotation is still an essential part of an integrated Sugar Beet Nematode control program. In sugar beet-growing areas not utilizing malt barley in rotation, further work is needed to adapt the biological method of trap cropping.

Potential Contributions

Use of trap crops could have potential benefit to sugar beet growers in several ways. (1) They could reduce the need for the nematicide, aldicarb. (2) They might help maintain short sugar beet rotations and increase grower profits, since sugar beets are the state's most profitable crop. (3) By reducing aldicarb use, the potential hazard to ground water contamination would be reduced. (4) Effective reduction in Sugar Beet Nematode by trap crops would reduce the potential impact if aldicarb is removed from the market. (5) Trap crops may be an effective means of recycling nutrients. The capture of residual nitrates would be particularly important in reducing ground water contamination. (6) Reducing the use of aldicarb would reduce hazard to growers and farm workers. (7) They would provide fall and winter cover for soils which are subject to severe wind erosion. (8) They provide high-quality organic matter to soils which have been somewhat depleted of organic matter as a result of intensive production for as long as 50 years. (9) And, they provide an additional source of income from grazing animals, thereby diversifying farm operations.

Farmer Adoption

Seed for trap crops has only recently become available, although it still is not available at local co-op's or retail seed stores. Sugar companies, which play a key role in change of practices, have been slow in promoting the practice of using trap crops. In 1995, however, one of the sugar companies sponsored an aggressive trap crop demonstration program. Since all sugar beet acreage is contracted, farmers are hesitant to utilize a practice if it is not promoted by the sugar beet company. Farmer cooperative's are a key element in the infrastructure in that they provide services which will be important to the selection of fields and timely planting of trap crops. Their service role is in procuring seed, assisting in taking soil samples, and in applying fertilizer and seed. To be successful, trap crops need to be planted before completion of the main crop (in this case, malt barley). Therefore, the role of the cooperative is in assisting the farmer in planting trap crops without the need to stop harvesting the main crop.

Operational Recommendations.

1. Farmers should plant trap crop radishes or mustard following malt barley harvest. 'Pegletta' and 'Adagio' radish and 'Metex' and 'Maxi mustard are the varieties which have proven effective to date.
2. These crops should be planted as soon as possible. Waiting until after all barley is harvested will greatly reduce the growth of trap crops and diminish the ability to reduce Sugar Beet Nematode populations.
3. To facilitate early planting at a busy time, trap crops can be stubble planted if loose straw is removed or burned and a disk drill is used. Alternatively, seed can be mixed with fertilizer and broadcast, provided that the seed is then covered with a harrow and/or cultipacker.
3. To encourage maximum growth, trap crops will need good soil moisture and at least 50 lb/acre of nitrogen fertilizer.
4. Candidate fields for trap crop use should be targeted in the spring before barley is planted. Soil samples for Sugar Beet Nematode analysis should be taken. Planting these fields first with an early barley variety, if given a choice will facilitate the early planting of the trap crop.
5. On sandy soils trap crops should be left over winter as cover and plowed down in the spring.
6. Trap crops can be grazed to advantage with lambs (cattle grazing has not been evaluated). Since these crops are cold hardy, grazing can be delayed until late October without significant loss of forage quality.

New Hypotheses

1. Trap crops provide a positive benefit, other than reduction of Sugar Beet Nematode, to succeeding sugar beet crops in that they improve soil conditions through high quality organic matter addition.
2. Trap crops planted on light-textured soils conserve soil if not plowed down in the fall.

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Final Results

SARE #91-23

Farm Improvement Club Network for Sustainable Agriculture

Location:
Montana

Funding Period:
September, 1991 - March, 1995

Grant Award:
$69,000

Project Coordinator:
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Objectives

1. Build a statewide network of at least 20 farm improvement clubs, made up of local groups of farm and ranch families, that will undertake scientifically based on-farm field trials and demonstration projects to meet their need for information on sustainable farming systems.
2. Increase the level of technical support from local agricultural professionals and institutions for farm improvement club project design, implementation and monitoring.
3. Disseminate the results of these on-farm field trials and demonstrations in at least the semi-arid region of the Inland Northwest: eastern Oregon and Washington, Idaho, Wyoming, Utah, Alberta and Saskatchewan.

Abstract of Results

AERO's farm improvement club program is increasing producers' interest in and adoption of sustainable agriculture farming systems, and is re-building economic vitality and a sense of community in many rural Montana communities. The farm improvement clubs are providing a vehicle for cooperation within rural communities to solve common problems. The specific stories we are hearing from club members about the club's role in coalescing people around issues of agricultural sustainability and healthy communities is an exciting development.

AERO's annual survey of farm improvement club members shows dramatic progress resulting from the program:

- Forty-seven percent of members reported direct economic benefits resulting from their project.
- The purpose of the clubs has broadened to include new enterprise and market development.
- The response from cooperating public agency and technical assistance providers has shifted from a simple growing interest in sustainable agriculture to a desire for more support from their institutions for the work they are doing with clubs. They like working with the clubs, have a better understanding of farmers' needs related to sustainable agriculture, and want to provide better service.
- The amount of information shared between clubs with similar, and even disparate, activities and interests is increasing. For example, the marketing cooperative started by an established horticulture club is serving as a model for a new club. The clubs that are experimenting with various legumes in their small-grains rotations and vegetable production have found a common interest, despite operating in very different enterprises, markets and agro-climatic regions.

The results clearly show 1) direct benefit to producers from their club participation; 2) an evolution of club interest from on-farm research to marketing and broader economic and community concerns; 3) an increase in information sharing; and 4) greater public agency commitment to the program; and 5) an increase in networking initiated directly by and among clubs.

Economic Analysis

Club members report a wide range of direct and indirect economic benefits due to the activities of the clubs. Over the course of the program, 47 percent of club members reported direct economic benefits resulting from their project. Other economic benefits result from social support and interdependence. Some clubs have gone beyond a group that experiments with new agricultural practices and crops, to a group that is economically interdependent. Some examples include forming a producers co-op and coordinating their crop production; setting up a marketing program; collaborating on seed buying; developing value-added enterprises. Several clubs have helped each other out economically by sharing financial planning concerns and assisting club members during illness. The number of clubs organized around building markets for and commercial development of sustainable agriculture products is growing each year, recognizing that this is a key to their long term economic success.

In a survey administered by AERO with help from Montana State University, club participants identified over fifty crops and livestock products with commercial potential that could be raised in Montana. Peas and lentils were the most frequently mentioned, followed closely by specialty small grains, oilseed crops and products, a variety of vegetables and livestock products. Garlic, herbs, forage and feed products, and several types of plants for the seed trade were also mentioned several times. Another 10 to 15 crops were also suggested.

Barriers to commercialization identified include: a lack of processing facilities; transportation difficulties; the absence of reliable markets for alternative crops and specialty markets; a lack of vision; marketing and distribution systems that do not function well; unwillingness of growers to take risks; and government programs that run contrary to sustainable agriculture practices. Rounding out the top ten were consumer disinterest; lack of capital, and a poorly organized sustainable agriculture industry.

Potential Contributions

The program is changing institutional roles and relationships. The traditional centralized, top-down relationship between land grant institutions and farmers is shifting so that, increasingly, the clubs are recognized as a source of innovation and information across the statenot simply recipients of the institutions' superior expertise. The agency technical assistance providers are turning out to be a valuable conduit of club information, as well, and have their own developing network among themselves and their agency peers.

The club program is bringing concrete change in how people farm. Many club members have adopted the practices or marketing tools they experimented with as part of their club project.

The club program is building community. Club members report that their participation is fun, and a source of support.

The club program is building leadership in rural communities. Club members are developing leadership skills as they learn how to create group projects that meet their own needs and interface with the public to share what they have learned. For many producers, leading a farm tour, reporting on their club at the annual meeting, facilitating a club meeting, and serving as a trainer at a workshop or orientation meeting is a new experience. Many have reported that these experiences boost their confidence in sharing what they learn with others and that their work is valuable. The group-oriented nature of the program provides an opportunity for participants to improve their skills in working and communicating with people, an essential skill for any leader.

The club program builds communication and connection between producers from seemingly disparate regions and enterprise types of agriculture across Montana. The state-wide network that clubs have access to includes a rich diversity of resources (human, knowledge, technical, biological). By tapping the network, participants are realizing that they are not isolated in trying something new, that cooperation can strengthen their economic and social positions, and that their efforts are part of a larger movement to change modern agriculture.

The farm improvement club program is serving as a national model. Programs borrowing from the AERO model are currently being developed in Iowa, Nebraska, New Mexico, Kansas, Ontario, Idaho, Washington, and Oregon.

The program has attracted the support of public agencies in Montana, an important step toward institutionalization. The state Department of Natural Resources and Conservation (NRCS) began sponsoring clubs in 1993, and the Montana NRCS is contributing significant in-kind resources.

We are not finished with the programwe are still learning and changing to meet the needs of this growing and maturing network of rural citizens.

Farmer Adoption and Comments

Almost all farmers and ranchers involved in the farm & ranch improvement clubs are doing something different than before their involvement. Change on the part of the participants practically goes hand-in-hand with their participation.

"We'd have never started our group if it wasn't for this AERO project, and because of this we've acquired some fairly useful data that we've collected ourselves. We know how it actually works on our own farm, rather than how it works at the university or at the experiment station. We have direct hands-on experience with the data so we have more confidence in it... I'm real happy we've been able to share and learn from everyone else, too."

— Bud Barta, Dryland Cereal-Legume Group

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Final Results

SARE #91-24

Specifying And Analyzing Whole Ranch Systems For Sustainable Range Livestock Reduction In Environmentally Sensitive Areas

Location:
Montana

Funding Period:
September, 1991 - December, 1994

Grant Award:
$290,000

Project Coordinator:
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Objectives

Economic analysis of ten ranches from the plains and foothill's region of Montana to determine the profitability of sustainable practices, analyze existing enterprises and determine the feasibility of additional sustainable practices. A sociological analysis identifying factors influencing the adoption of sustainable agricultural production practices.

Inventory condition and trend of vegetation and soil resources, analyze livestock selection, management and marketing practices and animal performance levels, analyze seasonal and yearlong forage supplies with livestock and wildlife demand and determine potential strategies of agricultural diversification. Evaluate microbial degradation of grain straw to enhance feed value and evaluate chaff catchers to reduce winter feeding costs.

Compare riparian vegetation, fish habitats, and fish populations along streams having different riparian management practices, analyze impact of wintering and calving livestock on riparian vegetation, stream banks, and fish habitat. Quantify the use pattern of wildlife ungulates on winter pastures and hay fields, determine the impact of cattle grazing on deer and antelope use of pasture and hay land, determine preferred forage for wildlife ungulates in the study area.

Demonstrate the establishment and productivity of alfalfa varieties, determine the economic feasibility of using fertilizer to increase yields on old alfalfa fields, determine the impact of fall and spring grazing on alfalfa mortality and subsequent yield and determine if sustainable practices used in forage production have a positive influence on plant health.

Determine the ability of sheep or herbicides to limit the spread of leafy spurge from small, distinct populations, determine the rate and spread of leafy spurge controlled with either sheep or herbicides, assess the cost of stopping the spread and develop and conduct educational programs to assist landowners in implementing control programs with sheep.

Abstract of Results

Utilizing a multi-disciplinary approach numerous variables were scientifically evaluated to determine their role in the sustainability of Western range livestock production systems. Up to twenty two enterprises from two Montana regions were used to develop the data base.

Financial sustainability is obviously the most critical parameter affecting the sustainability of this industry. Data gathered show animal unit (AU) investment ranging from $2150 to $2500 per AU with an average 400 AUs per unit. Debt to asset ratio's average 7.84 and 11.5 percent in the two study areas. All ranches were determined to be profitable and most were financially sustainable. However, if debt loads were to approach 40 percent, financial sustainability would be jeopardized on most ranches.

Competition for resources by wild ungulates are perceived to play a role in range livestock sustainability. Seasonal use patterns for Conservation Reserve Program (CRP), hayland (alfalfa), dryland wheat, upland and bottom land pastures were established. Alfalfa was preferred during most seasons. Based on survey data and estimated $864 (+/-$143) loss was incurred by each ranch operation, statewide. Respondents enrolled in CRP incurred less damage.

Riparian studies determined that grazing management schemes incorporating high bank stability and riparian vegetation vigor were the most sustainable when compared to other stream characteristics. Overwintering livestock in riparian areas was found to negatively impact woody vegetation and subsequently other stream characteristics.

Noxious weed invasion and subsequent herbicide use relative to resource sustainability concerns all ranchers. Data gathered from ranch units utilizing sheep show that certain weeds like leafy spurge can be effectively controlled by grazing whereas other species may require herbicide use to sustain the resource.

On ranch, cooperator assisted, research trials were used to evaluate the imports of alfalfa varieties on stand establishment, fertility requirements, and stand longevity. Alternative weed management methods were also researched on established alfalfa stands. These individual practices were aimed at increasing the total production of hay or the limited land resource bases these ranches have for the production of harvested roughages.

Potential Contributions

Recognized value of big game by viewing it as a resource rather than a detriment to sustainability. Big game is responsible for 1.8 million dollars spent in a two county area with a net population of approximately 5,000 people.

Ranchers are more aware of the effects of their management inputs on the environment, based on range site and condition studies, in the northern great plains.

In-depth economic analysis of cooperating ranches has resulted in better management and record keeping for numerous operations in the west.

Cooperators more fully recognize better management of winter feed, alfalfa, is important in maximizing sustainable inputs.

Ranchers have learned that management of riparian habitat is important in total sustainability of the resource.

Rural communities more fully recognize the importance of sustaining a profitable range livestock industry.

Cooperators, as well as other ranchers, have improved understanding of the sustainability concepts.

Recommendations that will arise from this study regarding sustainable practices will be made from scientifically tested results.

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Final Results

SARE #91-26

A Cover Crop System for Vineyard Pest, Weed and Nutrition Management

Location:
San Joaquin Valley, California

Funding Period:
January, 1992 - December, 1994

Grant Award:
$120,402

Project Coordinator:
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Objectives

1. Determine the impact of a legume-grass cover crops on leafhoppers, mites, and their natural enemies.
2. Determine the value of the cover crops as substitute for chemical fertilizers and its effect on the long-term, overall nutritional status of grapevines.
3. Determine the feasibility of cover crops as substitutes for herbicides in annual weed management in row berms.
4. Determine the costs and benefits of the cultural practices studied in terms of overall chemical inputs, yield, labor requirements and farm profitability.
5. Develop guidelines and integrated demonstrations of cover crop systems in vineyards for pest, weed, and vine-nutrition management.

Abstract of Results

This report describes a continuing on-farm project evaluating the use of two cover crop-based systems for pest, weed, and vine nutrition management in California vineyards. In two large vineyards, from 1992 to 1994, we compared two systems that used a winter annual, oat/vetch cover crop to a system that used clean-cultivation and conventional methods of chemical soil amendments and weed control.

In one cover crop system, we used the cover as dry mulch by cutting the cover biomass and placing it on row berms for weed suppression to reduce herbicide use. The other cover crop system was cut and left in row middles, but as in the clean-cultivated system, weeds on berms were controlled chemically. We also initiated two additional experiments in 1993 using a merced rye/vetch cover crop, to compare a cover/mulch system with clean cultivation in an Experiment Station vineyard; and to compare cover crops used as green manure and re-seed to a clean cultivated system. The cover crop systems were developed to increase the sustainability of grape production by reducing inputs of chemical pesticides and fertilizers. We determined the impact of these systems on vine-nutrient status, weed suppression, and arthropod pests and beneficials. We also developed relative cost budgets for each management system.

Our findings to date indicate that, if properly managed, winter annual, legume/grass cover crops can reduce the reliance of grape growers on insecticides and miticides used to control leafhoppers and spider mites.

If sulfur dust (used for disease control) was used sparingly in late Spring and early Summer, the presence of these cover crops increased early season activity of predatory mites, resulting in reduced spider mite infestations. Similarly, where leafhopper numbers were not very low and cover crops were properly maintained through early July, the presence of cover crops resulted in reduced infestations of leafhoppers. These reductions were attributed to enhanced activity of certain groups of spiders, which consistently attained higher densities in the presence of cover crops compared to the clean-cultivated systems.

Leafhoppers were also utilizing the cover crops as non-host crops which may have resulted in less time spent on vines. These differences in pest abundance could not be attributed to changes in plant quality, as these were not sufficiently strong to have significantly produced the observed effects on leafhopper densities. However, although it remains to be seen, we expect in the long term that cover crop use will affect plant nutrient and water status to an extent that will impact the performance and the abundance of insect and mite pests, further reducing the reliance on insecticides and miticides.

Cover crops can also produce positive effects on vine-nutrient status by the second or third year, but may produce negative effects if the cover or vineyard are poorly managed. The positive effect is usually delayed, and is best illustrated by the results from the one test site where, by the third year, the cover crop had contributed in excess of 75 lbs/A of nitrogen. These effects may take even longer in table grape

culture, where the cover crop (as grown in our systems) was not incorporated until the Fall, while weeds were allowed to grow in row middles. In table grape culture, apparently much of the nutrient content of the cover is used to grow the resident vegetation during the summer. Potassium levels were also enhanced by cover crops by the third year, and in some cases where cover crops were grown with great care (to produce high levels of biomass), increased potassium (and nitrogen) levels was observed by the second year.

The amount of dry biomass produced by cover crops for weed suppression varied between vineyards. During the spring and early summer, the mulched berms received 1800 to 8,726 lbs. of dry biomass, with a total nitrogen content of 33 to 109 lbs/A. To date, the results from the north coast site and from the San Joaquin valley indicate that with sufficient levels of biomass production, berm mulching should reduce the use of pre-emergence herbicides. The mulch, however, will not control all weeds equally. Perennial weeds such as field bindweed were not controlled, and we do not have enough data on yellow nutsedge to determine if mulching will be effective. We expect that in the long term, yearly accumulation of the dry mulch should incrementally increase the level of weed control resulting in substantial reductions in the use of soil-applied herbicides.

Economic Analysis (and Yields)

The effects of cover crops on grape yield and operating costs depended on grape culture (raisin versus table), and represented a trade-off in water, fertilizer, pesticide and resource use. Although significant differences in yields have not been realized in the commercial vineyards, raisin yields in the experiment station vineyard were increased by 900 lbs./A which is equivalent to an increase of approximately $450/A in gross returns by the second year of the experiments where cover crop biomass was used as dry mulch for weed suppression in row berms. Furthermore, the use of cover crops (despite greater water demand) would significantly reduce operating costs if savings are realized by reducing chemical inputs for mites and leafhoppers. These savings are expected to increase if cultural methods (e.g., raised beds with adjacent furrows for irrigation are used instead of flood irrigation) are modified to maintain satisfactory cover crop growth while reducing water usage.

Potential Contributions

A key feature of our on-farm research is that it simultaneously sought to develop and implement sustainable agricultural practices in grape production. It was conducted in large scale replicated trials on commercial farms, and was therefore visible to other farmers. Our research provided practical benefits to several aspects of grape production including insect, weed, and nutrition management. Our findings also contributed to the general understanding of the feasibility of developing and implementing sustainable crop production practices. *This is information that crosses commodity lines.* Our research also generated new hypotheses related to the interaction between vegetational diversification of agroecosystems, plant age, predator-prey interactions, and weeds ecology.

Grapes are the leading crop grown in California, with a total value of over $1.7 billion. Most growers incur direct costs in grape production by applying synthetic insecticides, acaricides, herbicides and nitrogen fertilizer. Our on-farm research sought to develop cost effective, non-chemical alternatives for the management of vineyard pests, weeds and vine nutrition. Our research has shown that, if managed properly, *cover crops directly and indirectly reduce pest and weed densities, and (potentially) minimizing the use of insecticides and herbicides, in turn resulting in significant reductions in operating costs.* By the third year, the system showed early signs of significant positive contribution to vine nutrient status, and increases in grape yield. Should these studies continue beyond this transition phase, we expect a substantial reduction in the need to apply synthetic chemical fertilizer, and insecticides and herbicides, while maintaining (or even increasing) grape yield and quality, and profitability of farming grapes.

Farmer Adoption

Perhaps the greatest contribution of our on-farm research has been the willingness of growers to take greater risks and reduce pesticide usage on their farm. The growers have also been closely involved in the design of our cover crop system. We have spent every available effort to modify the design to facilitate the adoption of this system under various management conditions. Preparation of seed bed, timing of planting, and irrigation practices have been some of the elements that were modified for the various farms used in our studies. Most importantly, our research has helped our cooperating farmers to adapt farming practices that incorporate cover crops in the management of their vineyards. Their adoption of this practice has also encouraged others to do the same.

Operational Recommendations

Cover crops which produce sufficient biomass will reduce weed growth in the row berms. However, they require the growers to increase their management level to successfully produce the cover cover crop in addition to the grapes. Timing of planting, water requirements, and cover crop selection are all considerations that will have to be taken into account for this method to be effective and accepted. For example, planting on raised beds that are bordered by irrigation furrows can substantially reduce water use, while maintaining the same quality cover crop.

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SARE #91-27

Development of Winter Wheat Cover Crop Systems for Weed Control in Potatoes

Location:
Aberdeen, Idaho and Patterson, Washington

Funding Period:
September, 1991 to December, 1994

Grant Award:
$42,141

Project Coordinator:
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Objectives

The overall goal of this project was to develop a winter wheat cover crop system that could be used for economical weed control in potatoes. A series of experiments were conducted to: 1) test the efficacy of using winter wheat as a cover crop for weed control in potatoes; 2) test the use of hybrid necrosis factors for replacing chemical removal of the cover crop once the potato crop was established; 3) generate and evaluate necrotic winter wheat hybrids for use as cover crops for potatoes; and 4) develop cytoplasmic male-sterile winter wheat adapted to the Pacific Northwest for commercial hybrid production.

Abstract of Results

Weeds are an economically important problem in potato production in the Pacific Northwest, but options for mechanical and chemical weed control are limited. Winter wheat is an effective competitor with summer annual weeds that infest potato fields in Washington, Oregon, and Idaho. Therefore, studies using a winter wheat cover crop system for weed control in potatoes were conducted at Aberdeen, Idaho and Patterson, Washington.

Fall-planted 'Weston' winter wheat was killed chemically at various times after planting potatoes the following spring. In 1992, winter wheat competed well with weeds and reduced weed biomass 43 to 97 percent, depending on treatment and location. However, U.S. No. 1 (marketable) tuber yields were reduced 51 to 60 percent by the combination of weed and cover crop competition. In 1993, the spring was much wetter than normal and the wheat cover crop system did not control weeds as well as in 1992. Weed biomass was reduced 15 to 94 percent at Aberdeen and 3 to 32 percent at Patterson. U.S. No. 1 yields were reduced 49 to 96 percent by the combination of weed and cover crop competition.

In addition to the cover crop trials, 55 necrotic hybrids were evaluated in two years. Significant variation in timing and severity of necrosis indicated that the hybrids may be useful as cover crops in a broad range of crops.

Economic Analysis

The economics of using a wheat cover crop weed control system were compared to a standard-practice weed management system used by commercial potato growers in Southeastern Idaho. Complete cost and return estimates, commonly referred to as enterprise budgets, were developed for both systems and were used as the basis for the economic comparison. The yield data from the Aberdeen plots were indexed and extended to a commercial-size Southeastern Idaho potato farm to facilitate the comparison.

All cover crop alternatives evaluated in both years show a decline in costs when compared to the standard-practice budget. However, the cost savings is not significant when compared to the total per acre costs of producing potatoes in Southeastern Idaho, which exceeds $1,400. Also, a substantial amount of the cost savings resulted from a decrease in the assessments paid by the grower. Assessments are based on yield, and the lower the yield, the lower the assessment cost.

The standard budget had herbicide costs of $34.37 per acre not found in the potato budgets using a wheat cover crop for weed control. In contrast, the wheat cover crop budgets had $11 of input costs not used in the standard budgets, including wheat seed and Roundup. Thus, the net difference in the value of herbicides and seed was approximately $23 per acre. Machine labor and fuel and lube were all higher with the standard-practice budgets. Machine repairs were slightly lower.

The relatively minor input cost savings with the wheat cover crop systems did not compensate for the substantial reduction in gross revenue, primarily from yield impacts and secondarily from quality adjustments to price. None of the cover crop weed control alternatives compete favorably with the standard practice budget on an economic basis

Potential Contributions

The technology being investigated is at a preliminary stage and is not presently amenable to on-farm testing. First, relying on a cover crop alone for weed control is too risky. Weed control with the cover crop system varied tremendously depending on environmental conditions in the spring. When weeds were not controlled, U.S. No. 1 yields were reduced 51 to 96 percent. Using a reduced rate herbicide application to supplement weed control with the cover crop may provide acceptable weed control. If the present difficulties with the cover crop system can be overcome, weed control with a modified winter wheat cover crop system could be accomplished with less herbicide input than is currently used, and soil erosion would be greatly reduced.

Potatoes generally require three to four weeks from planting until emergence, and fields are subject to severe wind erosion until sufficient canopy has developed to protect the soil. In addition, irrigated potatoes are also subject to water erosion from irrigation, especially when grown on sloping land. The winter wheat cover crop protects the soil from winter and spring wind erosion, and from spring water erosion. The wheat also could scavenge nitrogen not used by the previous crop and reduce nitrate leaching to groundwater.

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SARE #91-28

A Multidisciplinary Approach to Evaluate and Aid the Transition from Conventional to Low Input Pest Management Systems in Stone Fruits

Location:
San Joaquin Valley, California

Funding Period:
September, 1991 - March, 1995

Grant Award:
$299,814

Project Coordinator:
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Objectives

1. To develop management guidelines for stone fruits by comparing the economics and the effectiveness of environmentally safe, low-input systems for stone fruits to conventional pest management systems.
2. To determine the levels of brown rot disease in low input and conventional stone fruit orchards and the effects of nitrogen levels on stone fruit susceptibility to brown rot fungus, *Monilinia fructicola*.
3. To determine the "best suited" combination of cover crops species and methods for managing cover crops, with respect to suppression of nematodes in the soil and enhancement of beneficial arthropods in the trees.
4. To determine control achieved and comparative costs of non-toxic control strategies (e.g. pheromone confusion and *Bacillus thuringiensis*) for oriental fruit moth, *Grapholita molesta*; peach twig borer, Anarsia lineatella; and omnivorous leafroller, *Platynota stultana*.
5. To evaluate the postharvest life and quality attributes of selected stone fruit varieties growing under conventional and low input pest management systems.
6. To compare orchard blocks having conventional versus low-input pest management systems with regard to differences in percent organic matter, nitrogen rates, root development, and water retention.

Abstract of Results

During the past three years we have been working in four peach orchards owned by two large farming operations, assisting them in the transition from conventional to sustainable management systems. In each orchard, half of the block has been left under conventional management for comparison. Initially, we concentrated on insect pest management since several "sustainable" tools are available.

These tools, which replace broad spectrum pesticides, include oil sprays in the dormant season, a very specific insect bacteria spray (*Bacillus thuringiensis*) and mating disruption using pheromone confusion. We have also been slowly bringing down the nitrogen level in the trees to help in insect and disease management and using composts, manures and/or cover crops to supply nitrogen where feasible. *The results have demonstrated insect control in all four sustainable blocks to be as good or better than conventional blocks.* There have been some minor problems in one of the sustainable orchards with secondary insect pests. An economic analysis indicates the sustainable approach costs about $100/acre more than the conventional approach. One of the cooperating growers has been so pleased with the results that he will convert all his stone fruit orchards to the sustainable system in 1996.

Good progress was made towards a more sustainable approach to brown rot (the major fruit disease of peach) management. Three tools have shown promise: maintenance of moderately low tree nitrogen level, addition of organic composts to the soil and cleaning up of diseased, mummified fruits in the trees. Additionally, we observed a negative correlation between a yeast on the fruit and levels of brown rot. Methods of manipulating this yeast will be studied in greater detail in the future. In addition to less fruit disease, the application of compost to the soil has also shown a tendency towards better fruit quality and less fruit damage from insects.

Many side studies are being conducted to develop additional sustainable tools. These include cover crops for weed control on the berms, cover crops for nematode control and pheromone confusion for mating disruption of some secondary pests. Finally, a new planting was established on University property where numerous sustainable techniques are being evaluated and will be demonstrated to large numbers of visitors.

Economic Analysis

An economic comparison of the plots in 1993 and 1994 showed higher costs in the sustainable plots ranging from $40 to $200 per acre compared to conventional plots. On average, the difference was less than $100 per acre. This small increase in production costs should not be a significant barrier to the adoption of sustainable practices by peach growers.

Potential Contributions

The greatest benefit of this work is the reduction of broad spectrum (and generally more toxic) pesticides in the orchard. These have been replaced with more specific pesticides or non-toxic treatments thus protecting the ecosystem and providing for greater worker safety. *As many as three separate sprays applying a total of six lbs/acre of organo-phosphate insecticides were eliminated in our test plots.*

Areas Needing Additional Study

As we move towards more sustainable systems where we are trying to live with and manipulate pests rather than eliminate them, it is obvious we need to better understand the overall ecology of the whole orchard. In other words, we need more information on how all the organisms in an orchard interact with each other. In particular, the soil ecosystem deserves more attention. We need to better understand how soil microorganisms affect tree health & nutrient availability and how cover crops and soil amendments affect the microorganisms.

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SARE #91-29

Development of Sustainable Potato Production Systems for the Pacific Northwest

Location:
Columbia Basin, Washington; Snake River Valley, Idaho

Funding Period:
January, 1992 - March, 1995

Grant Award:
$330,000

Project Coordinator:
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Objectives

1. Collect and compile existing information on sustainable production practices for potato rotations and identify additional research and information needs.
2. Determine the effects of alternative rotation crop management practices on crop yield and quality, and weed, insect and disease populations and development.
3. Determine the feasibility of using green manure rotation crops and cover crops to reduce reliance on synthetic nitrogen fertilizer in potato rotations and reduce nitrate leaching and erosion.
4. Inform and train growers, field advisors and extension agents on the short and long term effects of sustainable crop management practices and on approaches for converting to sustainable systems.
5. Develop decision support system components that will assist producers in evaluating alternative production practices in terms of sustainability, environmental quality and profitability.

Abstract of Results

The initial draft of an information guide on alternative management practices for potatoes has been completed. The guide cites references on alternative cultural, nutrient, and pest management practices. The initial draft of a Pacific Northwest production manual for sustainable potato production systems is in the final stages of preparation. The manual will provide producers with information on the agronomic, economic, and environmental effects of alternative potato production practices, as well as approaches for converting to alternative management systems.

Potato growers in Idaho and Washington were surveyed to determine current production practices, major pest problems, levels of pesticide use, and information on production costs and yields. Survey results indicate a heavy reliance on herbicides, fungicides, and insecticides by the majority of potato growers. However, there was also significant interest in alternative pest control methods. Compared to conventional growers, organic growers placed greater emphasis on variety selection, crop rotation, green manures, and utilized a much wider variety of pest control strategies.

A number of alternative management practices have been used effectively in on-farm tests to control pests and supply nutrients to potatoes. Several mineral and biological compounds have been successfully used to selectively control Colorado Potato Beetle without producing any environmental contamination.

Rapeseed grown as a winter cover crop has reduced weed biomass from 50 to 96 percent in the following potato crop. White mustard green manures have also greatly reduced weed populations in potatoes. Studies have shown that by adding one post-hilling cultivation, potato growers should be able to reduce the total amount of herbicide applied by about 25 percent. Rapeseed, white mustard, sweet corn, and sudangrass have been successfully used to improve control of nematodes and soilborne potato diseases. Incorporation of sweet corn residues following harvest reduced Verticillium wilt in potatoes by 37 to 41 percent and increased marketable yields by 50 to 66 percent compared to previously fallowed fields. Following sudangrass green manures, Verticillium wilt of potato was reduced by 24 to 29 percent and U.S. No. 1 potato yields were increased by 24 to 38 percent compared to potatoes following barley or fallow. Rapeseed and sudangrass green manures provided up to 72 and 86 percent control, respectively, of root-knot nematode in the following potato crop. These results show that selected green manure and cover crops have considerable potential for reducing reliance on herbicides, fungicides, and fumigants.

Single season legume green manures such as Nitro alfalfa, Austrian peas, and hairy vetch have provided 80 to 100 percent of the nitrogen required by the following potato crop. If these crops are harvested to provide an additional economic return to the grower, the amount of nitrogen contributed to potatoes is reduced by about 40 percent. Nitrogen mineralization patterns for Nitro alfalfa and Austrian pea residues incorporated by fall plowing synchronized reasonably well with potato nitrogen uptake patterns. This resulted in relatively high nitrogen use efficiency and minimal nitrate leaching potential. On-farm tests conducted by growers showed that the inclusion of alfalfa hay or pea green manure in grain-potato rotations increased marketable potato yields by 8 to 18 percent with greatly reduced conventional fertilizer inputs.

A summary of an analysis of enterprise budgets for 18 matched conventional and organic farming systems shows that average material costs were lower for the organic systems, while labor costs were higher. However, there were no significant differences in overall fixed and variable costs or projected net returns for the two systems. Additional economic analyses of a number of alternative potato farming systems were also completed. Evaluating the farming systems on a rotational basis showed a significant economic benefit from including alfalfa or peas in grain-potato-grain rotations.

A computerized plant nutrient diagnosis and recommendation system was developed for crops grown in potato rotations. Use of the program should lead to more efficient use of plant nutrients and a reduced potential for nitrate leaching.

Potential Contributions

Nutrient Management. Results of this project show that alternative nutrient management practices can be practical and cost effective. Nitrogen fertilizer costs for commercial potato production in the Pacific Northwest range from about $75 to $135 per acre. Legumes grown as green manures can provide 80 to 100 percent of a subsequent potato crops nitrogen requirement, while harvested legumes can provide about 40 to 60 percent. Animal manures can supply sufficient nutrients to produce a high yielding potato crop and are often very low cost.

Pest Management. Fumigation of potato fields for nematode and Verticillium wilt control typically costs more than $200/acre. Rapeseed and sudangrass green manures grown prior to potatoes have provided up to 86 percent control of root-knot nematode, while sudangrass has reduced Verticillium wilt by 25 to 50 percent. Residues incorporated from a harvested sweet corn crop can significantly reduced Verticillium wilt and increase marketable yield of potatoes. Rapeseed cover crops also can reduce or eliminate herbicide applications in potatoes ($30 to $45/acre) without affecting yields. Depending on the weed species infesting a field, 0.5 to 7.5 lb/acre of herbicide could be eliminated by cultivation.

Economics. Analyses of alternative potato farming systems on a rotational basis show that adding crops such as peas, alfalfa, and canola to traditional grain-potato rotations can be cost effective.

Operational Recommendations

In areas with a relatively long growing season such as Western Idaho and the Columbia Basin in Washington, fall-planted legume cover crops can be a practical and cost effective means of supplying nitrogen to potatoes. However, in areas with shorter growing seasons such as eastern Idaho, fall-planted legume cover crops will likely not produce sufficient growth and nitrogen accumulation to provide adequate nitrogen for the following potato crop. In these areas, full-season cropping to legumes prior to potatoes should be considered. Delaying residue incorporation until the following spring should result in more efficient use of the legume nitrogen. Harvesting the legumes for hay or seed will reduce nitrogen contributions to potatoes by about 40 percent compared to green manure incorporation.

Yields of potatoes fertilized with a combination of animal manures and fall-planted green manures were similar to those of potatoes fertilized with conventional fertilizer sources. In many cases, animal manures were available at a relatively low cost. Potato growers should investigate the local availability of animal manure sources and consider the feasibility of including manure or compost application in their management system.

Potato growers rely heavily on high rates or sequential applications of herbicides for weed control because of the concern that root pruning resulting from cultivation will reduce marketable yields. Data from this project show that hilling plus one cultivation does not reduce marketable yields. Therefore, growers may be able to reduce herbicide applications by 25 percent or more if one cultivation was added to their weed management program. Growing full-season or fall-planted Brassica species such as rapeseed or mustard prior to potatoes should also help suppress weed populations and reduce the heavy reliance on herbicides.

Lengthening rotations and including rapeseed, mustard, or sudangrass as rotation crops or winter cover crops shows considerable potential for reducing reliance on fungicides and fumigants for disease and nematode control, while still maintaining an economically-viable farming system.

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SARE #91-30

Assisting Resource-Poor, Small-scale Farmers with Adoption of Low-Input Technologies Through a Client Participation Program of Cooperative Research and Extension at the Rural Development Center

Location:
Salinas, California

Funding Period:
September, 1991 - March, 1995

Grant Award:
$180,000

Project Coordinator:
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Abstract of Results

The major objective of this project was to establish a model program for advancing the goals of SARE through assisting resource-limited farmers (most of whom are Spanish-speaking, Mexican immigrants with farm laborer experience and experience with traditional farming practices in Mexico). The farmers enrolled as students at the Rural Development Center (RDC) near Salinas, California, to adopt alternative, sustainable practices in producing vegetables for market. The program consisted of weekly classes; production and marketing workshops; field days; a resource center of multimedia instructional and reference materials; a core Small Farm and Education Program, involving both classroom and field instruction and practice; a multipurpose Community Garden Program; and a compact demonstration project; all of which were either newly developed or revised as a part of the SARE project. Also included in the program were ìon-farmî research/demonstration trials comparing industrial production practices with alternative, sustainable practices in growing of a large variety of vegetables.

Prior to SARE there was little attention paid to alternative practices at the RDC. The curriculum was based on the industrial model of agriculture, with alternative practices considered almost as afterthoughts. Correspondingly, the student farmers showed very little interest in alternative practices, even though most of them were very familiar with traditional agriculture in their native Mexico. Thus, none of them used alternative practices by choice, opting instead to grow their crops using the same industrial practices prevalent in the Salinas Valley.

Now alternative practices and the sustainable model of agriculture prevail at the RDC and are beginning to make inroads elsewhere in the Valley. The curriculum and programs are now based on sustainable principals, emphasizing alternative practices. More importantly all of the student farmers, by initiative and choice, use alternative production practices. For example, more than half of the current class of student farmers are growing certified organic produce (or growing organically in transition to certification). The conversion of the RDC to an emphasis on alternative, sustainable agriculture has been dramatic, and it is abundantly clear that the RDC is now practicing and promoting land stewardship in its training and community outreach programs.

The use of cover crops at the RDC has expanded from near zero to nearly 100 percent. Incorporation of these green manures has noticeably improved soil fertility and tilth. Likewise, the use of other soil improving amendments, such as composts, have increased from near zero to common use. Plans are to eventually have all the farm under certified production from the present of approximate 25 percent already certified with approximately 25 percent in transition.

Before SARE, crop diseases and pests were controlled with chemical pesticides, which are now used only as a last resort; having been replaced by a combination of organically certified pesticides, biological control, and cultural practices.

Numerous on-farm research/demonstration trials revealed that vegetable production was as high or higher when nutrient requirements were met with composts or legumnous green manures compared to chemical fertilizers. Green manures in combination with compost consistently gave the best results. Use of other sustainable practices, such as minimum tillage and water conserving irrigation (e.g., drip irrigation), in these trials, led to their adoption, along with the use of organic amendments, by the farmers.

Energy input for successful production of vegetables was about the same for crops grown with composts as with chemical fertilizers during the first year of production; but in subsequent years energy input for compost produced crops was lower. Energy efficiency was generally higher with compost produced crops, compared to those produced with chemical fertilizers, and polycultures were considerably more productive and energy efficient than comparable monocultures. As with energy savings, net profits were generally similar during the first year for chemical fertilizer grown crops and those grown with composts, but were higher for compost-grown crops in subsequent years.

Potential Contributions and Farmer Adoption

Results of a survey revealed that participants in RDC programs have gained: valuable practical farming and business skills; confidence in their capabilities to learn; an understanding of agricultural alternatives; the realization that they can achieve goals; exposure to sustainable agricultural methods which they had not seen elsewhere in California agriculture; and a network of support for farmer-to-farmer information exchange and assistance. The survey also revealed that farmers trained in the use of alternative practices were more likely to be farming sustainably than those who were not.

The compost demonstration project has influenced the steady expansion, through the more than three years of the SARE project, in the use of soil organic amendments, the number of student farmers using them, and the acreage in, or in transition to, state organic certification. This project, and the routine use of organic amendments on the farm, is facilitating the teaching of students and farmers in the Salinas Valley about the importance of building up soil fertility and tilth, of taking advantage of on-farm and locally generated organic waste resources, and of minimizing crop production costs.

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SARE #92-2

Integrated Hog Farming and Market Gardening for Small Farmers in Tropical Areas of the Western Region

Location:
Island of Hawaii, Hawaii

Funding Period:
October, 1992 - September, 1994

Grant Award:
$36,000

Project Coordinator:
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Objectives

1. To demonstrate a farm which efficiently produces farrow-to-finish pigs and compost using the "deep litter" system.
2. To demonstrate a farm in which livestock production is well integrated with the efficient production of market garden and orchard crops, especially in regards to transforming green waste and animal waste problems into useful compost fertilizer.
3. To demonstrate that a farm which is more environmentally sustainable can also be more economically sustainable.
4. To explore the possibility of a composting cooperative in which orchard crop farmers who do not have a convenient source of nitrogen or necessary composting facilities, bring their green waste to the demonstration farm for conversion to compost.

Abstract of Results

This project demonstrates to a wide range of interested observers the possibility of sustainable small-scale integrated livestock and orchard/market garden production. In order to be sustainable the livestock waste must not lead to environmental degradation, especially in terms of water and air quality, and the total farming operation must provide a reasonably acceptable economic return to the farmer. A strong consumer demand for fresh pork makes conventional pig farming reasonably profitable. However, equally strong regulatory and social demands to prevent environmental problems are eliminating the possibility to continue conventional pig production practices.

In light of this problem, we considered pig production methods used in more urbanized areas of the world. The deep litter pig production system developed and practiced in the Netherlands and Japan seemed to have some potential for U.S. production. This project adapts the deep litter system to tropical conditions.

In order to utilize the animal waste, shredded green waste from orchard, market garden, and landscape operations is combined with manure to produce compost fertilizer. In the process water and air pollution related to pig-rearing has been eliminated. While labor requirements for materials handling have increased to a limited degree, human labor required for making compost is minimized by having the pigs naturally work the manure into the shredded green waste litter. It is hoped that the costs associated with increased materials handling labor will be off set by reduced purchases of off-farm fertilizer inputs.

Whether or not the deep litter system ultimately proves to be more profitable, the system will at least allow pig production to continue in a social and regulatory environment which is no longer able to tolerate conventional pig production.

Economic Analysis

Implementation and ownership costs associated with the deep litter system are being collected and financial returns to resources employed will be calculated. When Deep Litter compost was applied to the market garden crop of bananas, a savings of $201.00 per acre could be realized. If the farmer decided to sell the compost, instead of using it on his farm, he could have obtained a price of $30.00 per cubic yard.

Potential Contributions and Practical Applications:

The primary benefit is increased sustainability of the hog and market garden system. The deep litter system provides pig producers a cost-effective means of becoming environmentally responsible. Therefore, more innovative producers can continue to be reasonably profitable on a small but commercial scale. Deep litter pig production may prove to be more profitable than conventional approaches when the extra value of the composted crops is factored into the whole farm profitability. The net financial impact is still being analyzed as some crops are on annual cycles.

Farmer Adoption

Project cooperator George Kahumoku feels that the Deep Litter system was worth adopting, and that the system should be promoted statewide. He has received funding ($120,000 for a two-year period) from the Environmental Protection Agency to continue the project, which will utilize his farm as a model farm for the rest of the state pork producers. Both the Natural Resource Conservation Service and the Hawaii Department of Health will participate in the project.

Operational Recommendations

The Deep Litter system is dependent on funding to undertake construction; proper construction is imperative (see slides-hog containment area must slope slightly to allow gravity-flow of composted material); adequate size (an operation of at least 50 farrows is necessary to offset costs of construction); adequate, consistent availability of carbon sources (material used on this site included macadamia nut husks and shells and wood chips from local trees; other sources could include green waste from recycling sites/landfills, and wood chips and shavings from sawmills); and farmer willingness to utilize the final compost product to reap the full benefits of the system.

Areas Needing Additional Study

One area that warrants additional study is the expansion of the Deep Litter system to other farms in the state. As this was only tested on our cooperator's farm, which is considered a small farm, it would be beneficial to determine if a larger operation would experience the same success as was obtained here. It would also be worth exploring the potential for the marketing of organic pork from this system, in addition to the organic vegetables and fruit produced on this farm.

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ACE #91-2

Integration Of Aquaculture Into An Irrigated Farm To Improve Efficiency Of Water And Nutrient Use

Location:
University of Arizona Marana Ag Center, Hyder Valley, and Safford, Arizona

Funding Period:
October, 1991 - December, 1994

Grant Award:
$150,000

Project Coordinator:
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Objectives

The objectives of this project were to demonstrate the benefits and constraints of multiple uses of water by incorporating fish culture into irrigation waters prior to applying the water to plant crops. Available nutrients such as nitrate and phosphate and organic matter in fish discharge waters were determined from point sources. The effects of the discharge waters on soil nutrient levels, plant fertilizer requirements and plant yields were determined from soil and plant samples. Technical and economic reports documenting the results from different types of integrated systems have been prepared for a diverse audience.

Abstract of Results

Field trials have been conducted to find if integration of aquaculture into irrigated crop production improves efficiency of water and nutrient use. Aquaculture and agriculture have been integrated for greenhouse production of catfish and ornamental plants and for field production of catfish, tilapia, cotton and mesquite.

In systems integrating ornamental production with aquaculture, turf and low disturbance in-situ nursery production were most promising. A series of trials of aquaculture effluent as irrigation water for ornamental horticulture products were conducted. Most of the plants required supplemental fertilizer in addition to the nutrients contained in the aquaculture effluent to achieve optimum growth. This may have been due in part to relatively low nutrient loading rates in most of the experiments. Nitrogen in the effluent seldom exceeded 5 - 10 ppm. The use of high salt geothermal aquaculture effluent directly for nursery irrigation restricted the growth of some species while other presumably more salt tolerant species were not affected.

Use of existing irrigation facilities in established field production systems - storage ponds and conveyance canals - for culturing fish may also provide an economical alternative crop for irrigated field crops, in this case cotton. In our studies, major benefits of integrated systems were dual use of water for two crops, cotton and fish; net increases of NO_3-N, PO_4-P, and NH_3-N to irrigation water via fish effluent; regulatory compliance for discharge water from an aquaculture facility; and enhancement of best management practices resulting in reduced applications of nitrogen. In replicated field trials, cotton yields were not affected, nor were there any differences in soil nutrients, soil organic matter or petiole nitrate between the cotton plots irrigated with fish effluent or standard irrigation water.

In both greenhouse and field crop production systems, aquaculture effluent was found to be suitable for crop production, saving water and adding some nutrients. However, plants generally required supplemental fertilizer in addition to the nutrients contained in the aquaculture effluent to achieve optimum growth.

Economic Analysis

Budget analysis showed a gain in net income of $29 per acre of cotton when tilapia were grown in the irrigation ditches. Net income of the integrated system was $50 per acre with Central Arizona Project irrigation water and $166 per acre with water from wells. Without the government subsidy, cotton production alone and cotton production integrated with fish production were not economic with either source of water. A break-even analysis indicated that the fish price at which the addition of fish production would produce a positive gain in net income over that of cotton alone was $0.50 per pound with the cotton subsidy and $3.40 per pound without the subsidy.

The cotton budgets are based on budgets prepared by the Cooperative Extension Service, College of Agriculture, University of Arizona (Wade, et al. 1993). The fish production portions of the two integrated budgets are based on the results of the fish culture research at the Marana site which provided information on stocking density, survival rate, and feed conversion rate. Aquaculture experts provided information on probable prices, labor, material, and equipment costs. These are preliminary results and should be viewed with caution.

Potential Contributions

Integration of aquaculture and agriculture may improve the cost benefit ratio and environmental impacts of both plant and fish production, especially in the irrigated farmland of the arid Southwest. It may provide an alternative crop, a way to reduce pumping costs, reduce chemical applications and enhance soil health by increasing organic matter and microbial activity, and provide a profitable and environmentally acceptable effluent discharge strategy for fish farmers.

The results of these studies suggest that ornamental plant production can be integrated with aquaculture production. Both high intensity and low intensity ornamental crops and cropping systems were examined and found to be viable as integrated production systems. Of the systems investigated, turf and low disturbance in-situ nursery production were most promising. Turf grew well with aquaculture effluent as irrigation water and offers the advantage of high water consumption. Turf production is however land intensive and is site disruptive.

The use of aquaculture effluent for adapted plant production in a minimally disturbed desert nursery provides the opportunity to utilize this waste in a production system that does not require much land disruption and preserves the native plants and habitats present on the site. Furthermore, production of landscape and land reclamation plant materials with less than optimal nutrients may be desirable since these plants will be utilized in environments with low native fertility and may be better adapted for survival after transplanting.

Nutrients were higher in fish effluent than in well or CAP water in both the pond and canal systems of cotton-fish production systems, but the increases were not large enough to make a difference in the amount of fertilizer that needed to be applied based on best management practices. Because petiole analyses and pre-plant soil analyses were used to establish the amount of chemical nitrogen to be added to fields, the amount of chemical fertilizer applied was reduced by up to 40 percent of the average nitrogen application used by many Arizona cotton farmers in similar soils. Thus, an enhancement of best management practices and additional nutrients added from fish effluent, may result in a substantial reduction in fertilizer application. There had been some concern that fish effluent could add too much nitrogen to soils and actually increase nitrate leaching into the soil profile. Neither of the fish culture systems we used created this problem.

Using the fish pond water or canal water to irrigate crops also alleviates the problem of water disposal from a fish culture facility. Current EPA regulations do not allow disposal of fish effluent into an existing natural waterway. Therefore, using the effluent for crop irrigation prevents the need for special permits or water treatment prior to disposal.

Operational Recommendations

Following best managements practices and integrating small alternative cropping systems can save money and reduce chemical applications. Farmers in the Southwest may have had problems trying to rotate with specialty plant crops, but fish may be an easier alternative. Also, fish farmers should use their discharge water for irrigation, even if for a small area or share the water with a neighboring farmer.

Areas Needing Additional Study

We need to find out why aquaculture has been a difficult industry to develop and integrate into existing cropping systems. Fish culture in these systems also needs to be investigated further. We need to know the effects of field practices such as pesticide applications on the fish, how long fish can stay healthy in a ditch or pond with no water exchange, and the amount of time a farmer must spend on the fish component of the integrated system.

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ACE #91-3

Canola and Rapeseed as Enhancers of Soil Nutrient Availability and Crop Productivity in Cereal Rotations

Location:
Corvallis, Kalispell and Conrad, Montana.

Funding Period:
September, 1991 - December, 1994

Grant Award:
$153,000

Project Coordinator:
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Objectives

1. Study nutrient accumulation by brassica, cereal hay, and cereal grain crops; and legume, brassica, and legume-brassica green manure combinations.
2. Determine the effects of the above rotations on nutrient availability to a subsequent barley crops.
3. Identify the influence of rotations including brassica spp. differing in glucosinolate levels on populations and activities of soilborne plant pathogens and integrate rotational sequencing with biological control of seedling diseases.
4. Conduct on-farm demonstrations of legume-rapeseed green manuring.

Abstract of Results

A three-year rotational study of brassica cropping and green manuring effects on nutrient cycling and plant diseases in cereal-based cropping systems was conducted at three Research Centers of the Montana Agricultural Experiment Station. The sites included a sandy loam, a silty loam, and a clay loam soil and all had access to supplemental irrigation. In the first year of the study, canola or rapeseed grown as oilseed crops were generally at least as efficient as barley in acquiring plant nutrients from the soil, but a greater portion of these nutrients were concentrated in the seed. As a consequence, brassica oilseed production resulted in greater removal-by-harvest of nutrients than barley in some cases. Brassicas managed as green manures, which remained vegetative throughout the growing season, were highly efficient in plant nutrient uptake. Total amounts of nitrogen (N) ranged up to 145 to over 300 kg N/ha in brassica green manures, in excess of a legume pea green manure at the same sites in some cases. Nutrient content of brassica green manures in general was three to six times the amount found in a barley crop.

Grain yield responses in the second year of the rotation (1993) were site-specific. At a site where indigenous levels of nitrogen and phosphorus were relatively high, no significant response to first-year cropping systems was elicited. At a site where soil nitrogen but not phosphorus or sulfur were limiting, barley grain yields showed a significant response to the amount of nitrogen returned in crop residues or green manures the previous year, but no significant response to rotational phosphorus or sulfur was evidenced. At the site where both nitrogen and phosphorus are limiting to yield, second-year barley yields were dependent upon the amounts of plant nitrogen and phosphorus returned in the first year. *It is rare in rotational or green manuring studies to find these strong relationships between the amounts of cycled nutrients and subsequent yield responses.*

In addition, one site elicited significant increases in available soil potassium in the spring of 1993 due to green manuring, and subsequent crop potassium uptake was correlated with these levels. This study presents evidence that legume green manure mixtures can be utilized to increase the availability of soil nutrients other than nitrogen to subsequent crops.

Two sites elicited significant barley grain yield and nutrient uptake responses through a second year of barley cropping to first-year rotational components, indicating that the effects on nutrient availability can be expressed for two years of subsequent cropping. Notable is the continued effect on potassium availability.

We believe that the brassica green manures, because of their glucosinolate content, have the potential to aid in the control of soil-borne plant pathogens. However, the results obtained in this study indicate that a single year of cropping to brassicas is insufficient for a reduction of *Pythium ultimum* and other soilborne pathogens to occur. Research involving the long-term production of these crops is needed to define their role in disease suppression.

Potential Contributions

The potential benefits to agricultural producers include 1) increased cropping diversity through inclusion of brassicas in cereal-based cropping systems, 2) new green manure crops that provide expanded benefits to soil nutrient availability beyond those of traditional legumes, and 3) a decreased reliance on off-farm inputs by use of brassica rotations to more efficiently cycle nutrients on-farm.

Farmer Adoption

Seed samples of brassica forage and green manure varieties have been distributed to over fifty individuals in response to educational talks on brassica production for forage and green manure. The largest response has been for sheep forage. It's too early to assess adoption, as producers continue to explore niches in their systems for brassicas.

New Hypotheses

We are gaining the first evidence that brassicas can be managed to increase nitrogen, phosphorus, and potassium availability to subsequent cereal crops, and that cereal responses are specifically related to the amounts of nutrients cycled through previous year's crop residues or green manures. The high nutrient uptake capabilities of brassicas should be adapted to improve nutrient cycling in sustainable agricultural systems.

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ACE #92-8

Development and Evaluation of Indicators for Agroecosystem Health

Location:
Idaho and Washington

Funding Period:
October, 1992 - March, 1995

Grant Award:
$40,000

Project Coordinator:
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Objectives

1. Develop critical microbial tests and the Random Amplified Polymorphic DNA (RAPD) technique for determining the diversity and activity of microbial communities as affected by cropping system management, and to evaluate the use of bulked segregant analysis for the identification of microbial sequences linked to soil quality.
2. Correlate critical biological and chemical tests with the microbial indices for assessing soil quality in long-term research sites and farmer fields as affected by cropping system management.

Abstract of Results

The project on ecosystem health and soil quality indicators focused on how new approaches using molecular indicators and more conventional measurements could be used to determine how farming practices influence microbial populations and microbial diversity. Paired farms in Idaho and Washington comparing conventional rotations of wheat-pea with more complex rotations containing forage legumes and grass showed that soil from more complex rotations was generally higher in microbial indicators, microbial activity, soil organic matter, water infiltration, and pH. Cemetery sites were included to simulate native grassland sites. These same sites were used to evaluate a new technique, Random Amplified Polymorphic DNA (RAPDs), which attempt to look at diversity of extracted soil DNA to estimate the diversity of microbial communities. This technique showed that the microbial communities were different between the paired farms and the native grassland.

Findings

We have evaluated the use of Random Amplified Polymorphic DNA (RAPD) fingerprinting as a means of comparing soil microbial communities beneath various cropping systems. RAPD fingerprinting is a polymerase chain reaction (PCR) based technique that yields DNA products ranging in size from 200 bp to 2000 bp. When these products are separated on an electrophoretic gel, a banding pattern is observed that is very similar to a marketing bar code used in many stores. The RAPD fingerprint is characteristic of the target DNA and has been used to differentiate between closely related cultivars of wheat and barley, and to differentiate between closely related bacterial species. RAPD fingerprints would also be expected to be characteristic of different microbial communities, such as soil microbial communities exposed to different cropping practices. Before this technique may be applied with confidence to the evaluation of systems as complex as soil microbial communities, however, a number of preliminary studies must be conducted. With funds including those supplied by ACE, we have improved existing techniques for the isolation of DNA from soils, evaluated the composition of DNA as to the presence of prokaryotic and eukaryotic DNA, evaluated the technique in a simple model community (compost), and evaluated the technique in soils exposed to a variety of management practices.

DNA Isolation

We have found that RAPD fingerprinting is very sensitive to the presence of humic contaminants in DNA (much more sensitive than many other PCR based techniques), and have improved protocols developed in our laboratory to reproducibly yield high molecular weight DNA that is suitable for RAPD fingerprinting.

We are primarily interested in characterizing the bacterial, or prokaryotic, segment of soil microbial communities. The presence of fungal DNA would therefore confound our analyses. We believe that the protocol that we have developed isolates DNA primarily from prokaryotes, with little or no significant amounts of fungal DNA. The composition of the DNA was assessed by screening DNA isolated from soils with PCR primers specific to fungal DNA. No fungal DNA was detected by this approach.

Compost as A Model System

Soil microbial communities are extremely complex in nature, with potentially as many as 10,000 bacterial species per gram of soil. Before proceeding to a system this complex, we evaluated the technique in a model compost system present at Procter & Gamble, Cincinnati, OH (partial funding for this project was also supplied by Procter & Gamble). We developed the first procedure for isolation of microbial DNA from compost, and evaluated the use of RAPDs to detect shifts in the microbial community as it shifted from a thermophilic to a mesophilic community. The RAPD fingerprints were highly reproducible, attained a limit of detection of individual species of approximately 0.4 percent, and identified the predicted shifts in the microbial community.

Evaluation of RAPDs in Soils

We have shown that RAPD fingerprinting in soils can be very reproducible, yielding between 5 and 25 distinct bands. We have also shown that the limit of detection in soils is approximately 1 percent. The limit of detection in soils is higher than in the compost system and is likely to be a function of the complexity of the system; the more complex the system, the higher the limit of detection. RAPD fingerprints were generated that were characteristic of a variety of different soils, including those from a golf course, a natural grassland, and a conventional farm. In paired farm studies, specific RAPD bands were detected that were characteristic of conventional farms and of sustainable farms.

Limitations of the Use of RAPD Fingerprints to Characterize Soil Communities

The generation of RAPD fingerprints from DNA isolated from soil is technically difficult and this is the primary limitation in the technique. Students have been hired to conduct this research but have proven to have great difficulty in reproducibly obtaining useable fingerprints from soil DNA. Well-trained molecular biologists appear to be required to obtain consistently usable results.

Interpretation of data obtained by RAPD fingerprints is limited. Since these fingerprints are random, we do not know what organisms the individual bands arise from. As in the case mentioned earlier where characteristic bands were observed in conventional versus adjacent sustainable farms, we can not say what microorganisms are different in the different soils. We can only say that there are observable differences. This is not to say that RAPD fingerprinting does not have value in characterizing soil communities. In the right hands, it is a rapid and highly reproducible means of identifying differences between different soils, and perhaps may be very useful at identifying similarities or differences between sustainable operations.

Another possible limitation is the great complexity of soil. We have occasionally had difficulty obtaining reproducible fingerprints that is attributable to the great complexity of some systems (this has also been observed in fingerprinting barley chromosomes). It may be that the greatest utility of RAPD fingerprinting lies in characterizing relatively simple communities, such as compost. RAPD fingerprints could be used to identify properly versus improperly functioning compost facilities, as well as to characterize the maturity of compost.

Potential Contributions

Farmers who use green manures and more diverse rotations do so because they believe that there are long-term benefits. One of the growers who uses plow-down of clover believes that there are benefits, but current farm policies do not provide much incentive as one often loses wheat base. this particular grower also believes that the moldboard plow is the best way to turn under the residue which aids in improving soil tilth and water intake. However, current Natural Resource Conservation Service regulations normally do not allow farmers to use the moldboard as the regulations are based almost solely on surface residue. This one grower has attempted to use other options such as no-till, but the amount of green manure residue makes these practices difficult to use.

New Hypotheses

The feasibility of using soil DNA to determine microbial community structure has shown differences between farming practices. The challenge now is to determine what microbial communities these represent at the genus or species level.

Farmer Adoption

The lack of farmer adoption to using more diverse rotations, cover crops, and green manures is largely economic. Changes in the farm program which include more incentives would be a start.

Operational recommendations are to encourage more applied research and on-farm research to document the benefits of longer term rotations.

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ACE #93-10

Educational Video and Management of Pinyon-Juniper Ecosystems: A New Approach

Location:
New Mexico

Funding Period:
August, 1993 - July, 1994

Grant Award:
$20,000

Project Coordinator:
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Objectives

To educate ranchers, federal and state agencies, and the general public on a new approach in managing pinyon-juniper ecosystems for sustained use.

The educational method used will be a 25-30 minute video which will be designed to:

1. Reach the maximum number of viewers.
2. Change or reinforce public opinion regarding an appropriate management strategy in restoring watershed health.
3. Encourage land users of public and private lands to utilize native timber products to supplement incomes, thereby improving sustainability on family ranches and strengthening surrounding rural communities dependent on forest products.
4. Solicit public support for federal initiatives for increased investment in programs to improve watershed conditions.
5. Show the value of fire management in the maintenance of restored watersheds.
6. Show actual treatment methods and the dramatic results.
7. To train resource managers in the Forest Service to implement a new pinyon-juniper woodland management strategy.

Abstract of Results

An educational video entitled "Fire and Water: Restoring a Pinyon-Juniper Ecosystem" and a brochure entitled "Restoring a Pinyon-Juniper Ecosystem" have been produced for wide distribution. These educational materials address the issue of how to restore a deteriorated watershed in an environmentally and socially acceptable way.

The video and brochure document a successful approach used by ranchers and the U. S. Forest Service to deal with complex watershed restoration issues. The video demonstrates how various groups working together can blend environmental and economic needs in a fashion that allows for clean water, clean air, fish and wildlife, diverse recreational opportunities, profit from livestock ranching and community business and an aesthetically pleasing environment. The video will apply to many areas throughout the West where similar problems and opportunities exist in pinyon-juniper ecosystems.

The 30-minute video brings together diverse views from Hispanic, Native American and Anglo cultures as well as environmental and traditional agriculture concerns. Four hundred and fifty copies of the video and 5,000 copies of the brochure have been produced and distribution has begun. The video is designed to educate a wide variety of audiences, including federal and state agencies, ranchers and the general public.

A significant benefit of this project is already taking place in the classroom. A shorter version of the video is being distributed to high school students in New Mexico to be used to debate the pros and cons of "friendly" fire and brush control in manipulation of our natural environment.

Potential Contributions

The video will have a positive impact on conservation efforts in two areas: 1) the public will be better informed and therefore less likely to object to beneficial but sometimes controversial practices such as prescribed fire or brush control; and 2) the land users and governmental agencies who are directly involved in resource management will be encouraged to undertake watershed restoration projects.

The video and brochure detail specific benefits related to restoration efforts. For example, the brochure indicates that as much as *20 tons* per acre of topsoil are lost on severely eroded sites. The video documents the restoration of springs that have been dry for years due to competition from juniper for available ground water.

The restoration approaches demonstrated in the video will be applicable to many areas throughout the West. In the Southwest region alone, there are three and a half million acres of deteriorated pinyon-juniper on Forest Service lands, not to mention the adjacent private lands. The success story of this project can be duplicated in similar areas.

Another positive benefit will be in educating our youth. This project has been selected as an environmental education activity of high school students in New Mexico.

New Hypotheses

State and federal agencies charged with meeting environmental regulations such as the Clean Water Act are beginning to look at ecosystem management or holistic management on watershed boundaries as the way to address water quality and other resource problems. For example, in New Mexico, the State Environment Department and the Environmental Protection Agency is beginning to work with local people to develop water quality plans on deteriorated watersheds. The video illustrates how this can be done successfully and can be used to show these agencies a successful strategy to reach environmental goals.

The video also documents the additional water yields based on elimination of a substantial amount of competing vegetation (Juniper). This is a controversial issue and many researchers will dispute the claim that removing competing trees will increase water yields. The video documents this phenomenon on the Carrizo Project and perhaps this will encourage additional research in this area.

Farmer Adoption

The full impact of the video on ranchers, researchers and government agencies has yet to be determined. Early response to the video by groups and individuals has been encouraging. Requests from Bureau of Land Management and State Environment Dept. to show their staffs the video is encouraging. The Forest Service plans to use this video extensively in their training programs. They will distribute at least 300 copies of the videos for their own use.

Ranchers who are in the immediate area of the Carrizo Project are working on similar programs on their private and leased lands. There is definitely an increase in prescribed fire, brush control and erosion control on both public and private lands as a result of this initiative.

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ACE #93-13

A High-Input Crop Production System in Coastal California as a Model for Developing Indicators of Agroecosystem Sustainability

Location:
Monterey County, California

Funding Period:
September, 1993 - March, 1995

Grant Award:
$40,000

Project Coordinators:
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Objective

Develop a baseline characterization of potential indicators of agroecosystem health at a long-term agricultural research site in the Elkhorn Slough watershed, Monterey County, California.

Abstract of Results

Our original proposal to the USDA-ACE Program was for a three year project to examine the influence of vegetated buffer strips on nonpoint source pollution from crop lands and its influence on an adjacent wetland. We received one year of funding which allowed us to complete a baseline characterization of the site. Planting of vegetated buffer strips will begin in 1995, with funding from another source. Data from this study will be used to assess the relative effectiveness of different vegetated buffer strips treatments.

The Azevedo Ranch research site encompasses 150 acres, approximately 120 of which are currently in strawberry cultivation. The land, which is owned jointly by The Nature Conservancy and the Monterey County Agricultural and Historical Land Conservancy, will be managed in perpetuity as a research and demonstration site for sustainable land management practices. The property will be divided into a wetlands buffer zone surrounding three "pocket marshes" and an upland agricultural zone. The buffer zone, which is currently in cultivation, will be restored with native vegetative cover including native bunch grasses, Coast Live Oaks, and maritime chaparral. The upper agricultural zone will encompass 83 acres and will eventually be converted to low-input sustainable agriculture. The overall goal is to develop models, for the greater watershed, of ecologically and economically sustainable methods for crop production. Because this is a report of baseline characterization of the study site, our emphasis is on findings, rather than applications or farmer adoption, which will come in a later phase of the long-term project for which funding is being actively sought.

The land-use history, site and soil characteristics, infiltration rates, earthworm abundance, nitrogen and phosphorous in runoff, nitrate in soil water, and sediment transport, and arthropod populations were collected and quantified for the upland portions of the site. In the wetlands we quantified benthic invertebrates, salt-marsh plants, and water quality (temperature, salinity, oxygen, turbidity, pH, and nutrients, including total phosphorous, phosphate, nitrate, nitrite, and ammonium).

New Hypotheses

Our work to date at the Elkhorn Slough has generated increased interest in examining the potential benefits of vegetated buffer strips between the cultivated portions of the Azevedo Ranch and the wetlands. With additional funding, we will study the mechanisms by which vegetated buffer strips can be used to reduce the movement of nonpoint source pollutants from farmland to wetland. We are specifically interested in the transport and fate of sediment, nitrogen and phosphorous in surface water, and nitrate-nitrogen in sub-surface water. We will compare native perennial bunch grass vegetated buffer strips with vegetated buffer strips comprised of annual grasses. We will measure nitrogen pools and pathways in order to contribute to our understanding of nitrogen budgets in the row-crop/vegetated buffer strips systems. Results of this study will be used in the design of vegetated buffer strips for Mediterranean climates, with the goal of protecting wetlands while developing ecologically sound agricultural practices. This study will also contribute to the regionally important goal of restoring native wetland and upland habitat at Elkhorn Slough, and in other California wetland areas.

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ACE #93-14

Introduction of Cover Crops into Annual Rotations in Northern California

Location:
Northern and Central California

Funding Period:
September, 1993 - December, 1994

Grant Award:
$21,199

Project Coordinator:
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Objectives

1. To collect and compile information on the practices currently in use for managing cover crops in annual rotations in the Sacramento Valley and Delta regions.
2. To produce a comprehensive summary of the problems associated with inclusion of cover crops in rotation with major annual crops and identify those problems and potential management options appropriate for further research.

Abstract of Results

Cover crops have many potential benefits in annual cropping systems and may enhance the sustainability of these systems. Although a significant cover crops research and extension effort has been made in California in recent years, relatively few California farmers have adopted the use of cover crops in their annual crop rotations. To address this situation, several researchers and extention personnel working with cover crops concluded that it was necessary to survey farmers about their cover cropping practices, attitudes and needs. This information will be used to set priorities for future cover crops research and education efforts and to provide information to farmers about various cover crop management options.

The survey was conducted by telephone interviews with 119 producers of annual crops in California's Central Valley. The survey questionnaire was developed by a multidisciplinary team of researchers and extension specialists with significant help and advice from county farm advisors. Of the 119 farmers surveyed, 29 grew cover crops. Compared to the non-user group, cover crop users tended to be younger, more educated and have fewer years farming experience and their farms tended to be smaller and more diverse. Cover crops were grown by eighty-seven percent of the organic growers, but only eleven percent of the conventional growers in the survey.

The survey showed that winter cover crops are preferred over summer cover crops with 88 percent of the users growing winter cover crops and 31 percent growing summer cover crops. Over 80 percent of the winter cover crop growers grew vetch cover crops and most planted their winter cover crops at about the same time. However, there was a significant amount of variation in the amount of field work performed both before and after growing the cover crops.

There were over twenty-five potential advantages of cover cropping listed by growers. Cover crop users tended to list more benefits that non-users. For both groups of growers, the most commonly stated advantages of cover crops were that they can provide nitrogen and increase soil organic matter. There were also several potential disadvantages and barriers to use of cover crops indicated by growers. The most common reasons cited for not growing cover crops were that winter cover cropping necessitated unacceptable delays in spring planting, that a cash generating crop could be grown in place of a cover crop, and that the total costs associated with cover cropping were too high for the perceived benefits.

The growers surveyed indicated a strong interest in information about cover crops. The greatest demand was for information about different types of cover crops for specific situations and/or with specific qualities and about the specific effects of cover crops on various aspects of the cropping system. Of the non-cover crops users, twenty percent indicated that they were considering trying cover crops while over two-thirds were interested in learning more about cover cropping and one third were interested in participating in on-farm research on cover crops.

This survey confirmed that relatively few growers are using cover crops, but also indicated that there is significant interest in cover crops on the part of non-users. In addition, cover crop users have a wealth and diversity of cover crop knowledge and experience which is potentially very valuable to other farmers and researchers. The information collected in this survey will be invaluable in developing research and extension priorities in the future and should prove very useful to growers wishing to learn more about various cover crop management options.

Economic Analysis

It was beyond the scope of this study to do an economic analysis of the 119 farming operations which participated in the study. However, the survey results indicated that economic play a role in growers' decision regarding cover cropping. Among some of the most frequently mentioned reasons for not growing cover crops or not growing cover crops on a higher percentage of field and row crop acreage were the belief that the overall cost of growing a cover crop was too high and the resistance to replacing a cash crop with a cover crop because of the loss of direct economic benefit

Potential Contributions

Because this project surveyed growers regarding their practices and attitudes and did not attempt to develop any new practices, it was not intended to have a direct impact on farming operations or communities. Rather, it was intended to impact research and education efforts in the future. As stated in the project proposal, the long term goal of the project was "to increase the use of cover crops in annual rotations." Because only some of the benefits of cover cropping in annual systems have been definitively documented and quantified, only a partial analysis of the effects of increasing cover cropping is possible. Based upon previous work by the project leader and others, it has been demonstrated in on-farm trials that cover cropping can significantly reduce the need for synthetic nitrogen fertilizers. This reduction can represent substantial energy savings because the production of nitrogen fertilizers requires large amounts of energy.

Based upon our previous work, cover cropping can replace approximately 150 pounds of nitrogen fertilizer per acre. Comparing the total energy use in fertilizing in a previously cover-cropped and a synthetically-fertilized crop, the cover cropped crop uses four million BTUs (or 65 percent) less energy than the synthetically fertilized crop. As pointed out by many of the growers surveyed in this study, cover crops have many other benefits related to soil tilth, soil-water relations, pest management, etc.

New Hypotheses

The two most interesting new ideas or hypotheses to emerge from this project are as follows:

1. It may be most fruitful to consider that there exist two fairly distinct groups of growers: cover crop users and cover crop non-users. These two groups appear to have different priorities and needs with regard to cover crops research and extension.
2. Future grower education projects should include experienced growers as educators. While we have previously conducted on-farm demonstrations and included growers in our educational programs, our survey results indicate that some of the more experienced growers have a wealth of information which is useful to inexperienced growers. Much of this information is not really known by researchers or even extensionists. We believe that in an area which is evolving as rapidly as cover cropping, a team effort by experienced growers and research/extension personnel, as equal partners in the educational process, has the greatest potential to effectively educate growers wishing to learn more.

Farmer Adoption

The results of the survey indicate that there is potential for much more widespread adoption of cover crops in annual systems in these regions. Twenty percent of the farmers surveyed who were not currently growing cover crops indicated that they are considering it as a viable option. The potential for higher adoption rates is also demonstrated in the high level of interest growers had in the educational activities related to cover crops in annual cropping systems.

Areas Needing Additional Study

The survey asked farmers if they had any suggestions for further research on cover crops in annual cropping systems, and if there was any information that they wanted about cover crops that was not currently available to them. The research suggestions that growers gave spanned a wide spectrum (more than forty different ideas were mentioned) and there was a lot of overlap with the responses to the question about information needs. The largest number of suggestions fell into two broad categories. The first category is that farmers want more information about new or existing cover crop varieties that can fit into a particular type of crop rotation, grow well in a particular soil or weather conditions, or possess certain characteristics (such as high biomass, fast growth, extensive root system or high nitrogen content). The second category of research and information that farmers were most interested in was the effects that cover crops have on parameters such as nutrient availability, soil structure, water use, weed composition and insect populations. Other categories of research and information suggestions that farmers gave were economic information (such as cost-benefit analyses) and operational information (such as different types of equipment and best times for planting and incorporating the cover crops).

Western Region 1994 SARE Active Projects

SARE#	Project Title	Project Coordinator	State	Amount (94-95)
LW93-33	Development of Sustainable Crop and Livestock Production Systems for Land in the Conservation Reserve Program (CRP)	Kirksey	NM	$104,000
LW93-34	Four Corners Navajo Nation Sustainable Agriculture Demonstration Project	McNeal	UT	$100,000
SW94-006	Legume Cover Crops in Fallow as an Integrated Crop/Livestock Alternative in the Northern and Central Great Plains	Krall	WY	$160,000
SW94-008	Fall-Planted Cover Crops in Western Washington: A Model for Sustainability Assessment	Anderson	WA	$80,000
SW94-017	The Transition from Conventional to Low-Input or Organic Farming Systems: Soil Biology, Soil Chemistry, Soil Physics, Energy Utilization, Economics and Risk	Temple	CA	$186,666
SW94-022	Western Region Community Supported Agriculture (CSA) Conference	Lawson	CA	$23,991
SW94-023	Apple Production Without the Input of Neuroactive Insecticides	Brunner	WA	$268,000
SW94-029	Development and Demonstration of Integrated Vegetable Production Systems for the Maritime Pacific Northwest	Luna	OR	$80,000
SW94-034	Western Integrated Ranch/Farm Education	Hewlett	WY	$90,000
SW94-037	Sierra County Alternative Agriculture Project	Joos	CA	$12,000
SW94-054	Farming in the 21st Century: A Documentary Photography Project	Vagnetti	DC	$27,000
	Planning & Development			$83,483
TOTAL				**$1,215,140**

Western Region 1994 ACE Active Projects

ACE#	Project Title	Project Coordinator	State	Amount (94-95)
AW92-9	Comparative Performance and Farm-Level Function of Conventional and Certified Organic Apple Production Systems in California	Swezey	CA	$55,224
AW93-11	Calibration of the Pre-Sidedress Soil Nitrate Test to Improve Nitrogen Management on Dairy Farms	Christensen	OR	$25,376
AW93-12	Range Monitoring in the Upper Stony Creek Watershed	Gaertner	CA	$26,400
AW94-003	Compatibility of Livestock and Water Birds on Improved Pastures	Glimp	NV	$33,333
AW94-010	Management of an On-Farm Composting System	Miller	UT	$15,000
AW94-020	Rotational Management of Wetlands and Croplands in the Tulelake Basin	Shennan	CA	$259,633
AW94-033	Influence of Cover Crop and Non-Crop Vegetation on Symphylan (Scutigerella immaculata) Density in Vegetable Production Systems in the Pacific Northwest	William	OR	$66,667
AW94-000	Communication Specialist	Kelleher	CA	$12,500
TOTAL				**$494,133**

Western Region 1994 Professional Development Active Projects

SATP#	Project Title	Project Coordinator	State	Amount (94-95)	Duration
EW94-003	Multidisiplinary On-Site Training in Sustainable Agriculture Education	Temple	CA	$71,000	2 years
EW94-006	Sustainable Agriculture Training Project: A Model of Collaborative Learning	Matheson	MT	$91,000	2 years
EW94-008	Pacific Northwest Sustainable Agricultural Systems Training Program	Luna	OR	$78,000	1 year
EW94-009	Permaculture Systems Pamphlet	Osentowski	CO	$5,620	1 year
EW94-014	Training "Agents" in On-Farm Implementation of Sustainable Management Systems for Tropical Agriculture in Hawaii and the Pacific Region	Lai	HI	$89,000	1 year
EW94-018	Extension Sustainable Agriculture Training in Colorado and Wyoming	Hiller/Lamm	WY/CO	$75,000	1 year
ECW94-003	Western Region Sustainable Agriculture Training Network/Consortium Coordinator	Auburn	CA	$94,000	1 year
TOTAL				**$503,620**	

Western Region Sustainable Agriculture Research and Education
Project Funds Allocated in 1994 by State

State	SARE	Matching	ACE	Matching	Ch. 3	Matching	1988-1994 Cumulative Grant Funds (All programs)	1988-1994 Cumulative Matching Funds
Alaska	—	—	—	—	—	—	**59,983**	**78,639**
Arizona	—	—	—	—	—	—	**230,468**	**153,355**
California								
University of California, SW94-017	186,666	321,288						
Homeless Garden Project, SW94-022	23,991	20,388						
Sierra County, SW94-037	12,000	3,975						
University of California, SW94-054	27,000	371,200						
University of California, AW92-9			55,224	112,980				
University of California, AW93-12			26,400	22,800				
University of California, AW94-020			259,633	121,118				
University of California, EW94-003 ✱					71,000	59,512		
Subtotals	***249,657***	***716,851***	***341,257***	***256,898***	***71,000***	***59,512***	**3,244,959**	**3,698,490**
Colorado								
Colorado State University, SW94-006 ◆	57,260	96,000						
CRMPI, EW94-009 ✱					5,620		**120,230**	**120,000**
Hawaii								
University of Hawaii, EW94-014 ✱					89,000		**551,530**	**537,000**
Idaho	—	—	—	—	—	—	**248,306**	**520,223**
Montana								
Montana State University, SW94-006 ◆	18,344	48,798						
Montana State University, SW94-034 ❑	18,146	131,768						
AERO, EW94-006 ✱					91,000	203,857		
Subtotals	***36,490***	***180,566***	—	—	***91,000***	***203,857***	**825,598**	**1,058,177**
Nevada								
University of Nevada, AW94-003	33,333	11,760					**43,333**	**11,760**
New Mexico								
New Mexico State University, LW93-33	104,000	66,205					**404,050**	**291,667**

Western Region Sustainable Agriculture Research and Education
Project Funds Allocated in 1994 by State

State	SARE	Matching	ACE	Matching	Ch. 3	Matching	1988-1994 Cumulative Grant Funds (All programs)	1988-1994 Cumulative Matching Funds
Oregon								
Oregon State University, SW94-029	80,000	56,869						
Oregon State University, AW93-11			25,376	10,029				
Oregon State University, AW94-033			66,667	13,333				
Subtotals	***80,000***	***56,869***	***92,043***	***23,362***	—	—	**960,659**	**970,862**
Utah								
Utah State University, LW93-34	100,000	88,000						
Utah State University, SW94-034 ❑	18,334	48,798						
Utah State University, AW94-010			15,000	20,600				
Subtotals	***118,334***	***136,798***	***15,000***	***20,600***	—	—	**350,084**	**337,898**
Washington								
Washington State University, SW94-008	80,000	10,000						
Washington State University, SW94-023	268,000	34,916						
Washington State University, EW94-008 ❋					78,000	24,123		
Subtotals	***348,000***	***44,916***	—	—	***78,000***	***24,123***	**1,284,391**	**792,979**
Wyoming								
University of Wyoming, SW94-006 ◆	66,740	96,000						
University of Wyoming, SW94-034 ❑	53,331	104,715						
University of Wyoming, EW94-018 ❋					75,000	14,062		
Subtotals	***120,071***	***200,715***	—	—	***75,000***	***14,062***	**357,091**	**503,661**
Regional Initiatives								
Auburn, regional training coordinator					94,000	13,870		
Kelleher, regional communications specialist			12,500	3,500				
Vagnetti, communications initiative	27,000	36,000						
Subtotals	***27,000***	***36,000***	***12,500***	***3,500***	***94,000***	***13,870***	**133,500**	**53,370**

❑ ◆ - Joint projects split between several states.
❋ - Projects targeted to multi-state audiences.